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NATIONAL DAM SAFETY PROGRAM. UPPER LAKE MINNIE HA-HA DAM (MO-30--ETC(U)

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UPPER LAKE MINNIE HA-HA DAM MO 30643

LOWER LAKE MINNIE HA-HA DAM MO 30644

LAKE MINNIE HA-HA DEVELOPMENT,

STE. GENEVIEVE COUNTY, MISSOURI

DTIC ELECTE 1981

PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

United States Army
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St. Louis District

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PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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DECEMBER 1979

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Upper Lake Minnie Ha-Ha Dam (Mo. 30643) and Lower Lake Minnie Ha-Ha Dam (Mo. 30644) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Upper Lake Minnie Ha-Ha and the Lower Lake Minnie Ha-Ha Dams:

It was prepared under the National Program of Inspection of Non-Federal Dams.

Each of these dams has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1. Spillway will not pass 50 percent of the Probable Maximum Flood.

2. Overtopping of the dam could result in failure of the dam.

3. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — 14 JAN 1980
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 14 JAN 1980
Colonel, CE, District Engineer — Date

UPPER LAKE MINNIE HA-HA DAM - MISSOURI INVENTORY NO. 30643

LOWER LAKE MINNIE HA-HA DAM - MISSOURI INVENTORY NO. 30644

STE. GENEVIEVE COUNTY, MISSOURI

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM.

Upper Lake Minnie Ha-Ha Dam (MO-30643), Lower Lake Minnie Ha-Ha Dam (MO-30644), Mississippi - Kaskaskia - St. Louis Basin, Lake Minnie Ha-Ha Development, Ste. Genevieve County, Missouri. Phase I Inspection Report.

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

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PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dams:	Upper Lake Minnie Ha-Ha Dam
	Lower Lake Minnie Ha-Ha Dam
State Located:	Missouri
County Located:	Ste. Genevieve
Stream:	Tributary Saline Creek
Date of Inspection:	19 September 1979

The Upper Lake Minnie Ha-Ha Dam and the Lower Lake Minnie Ha-Ha Dam, both of which are located in the development known as Lake Minnie Ha-Ha, Inc., a Missouri corporation, were visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dams with respect to safety and, based upon these inspections and available data, determine if these dams constitute a hazard to human life or property. The Upper and Lower Lake Minnie Ha-Ha Dams are under common ownership and, for that reason, the investigation findings for both lakes are contained in this one report.

Upper Lake Minnie Ha-Ha, the larger of the two lakes, has a surface area of approximately 18 acres, and is located immediately upstream of Lower Lake Minnie Ha-Ha, which has a surface area of about 6 acres. The relative location of the two lakes is shown on Plate 2 of this report.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection, the present general physical condition of both dams is considered to be somewhat less than satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of these dams.

1. At the time of the inspection, the upstream and downstream faces of both dams supported a dense cover of high grass and/or brush that could conceal animal burrows, as well as numerous small trees. Animal burrows and tree roots provide pathways for lake seepage, which could develop into a piping condition and subsequent failure of the dam. The plant cover should not be allowed to grow to a height that provides cover for burrowing animals or hinders inspection of the dam.

2. An animal burrow with consequent erosion of the embankment was noted at the toe of slope on the downstream face of the Upper Lake Minnie Ha-Ha Dam near the right abutment.

3. Underseepage, as evidenced by soft ground, cattails and flowing water, was observed at or near the downstream toe of slope of both dams. Uncontrolled seepage can develop into a piping condition that could result in failure of the dam.

4. The upstream face of the Lower Lake Minnie Ha-Ha Dam has a grass cover to prevent erosion. A grass cover is not considered adequate protection to prevent erosion of the embankment by wave action by a fluctuating lake level. Embankment erosion could result in a loss of section that may lead to instability of the slope and possible failure of the dam.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for these dams, which are classified as small in size and of high hazard potential, is specified to be a minimum of one-half the Probable Maximum Flood (PMF). Considering the fact that a fairly large volume of water is impounded; that two county highway bridges are located nearby downstream; and that several dwellings as well as the Town of Minnith lie within the possible flood damage zone, it is recommended that the spillways for these dams be designed for the PMF. The Probable Maximum Flood (PMF) is the flood that

may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that the existing spillways are capable of passing lake outflows corresponding to the following percentages of PMF lake inflows, without overtopping their respective dams:

Lake Spillway	Percent PMF
Upper Lake Minnie Ha-Ha	17
Lower Lake Minnie Ha-Ha	31

In the determination of lake outflow for the Lower Lake Minnie Ha-Ha, runoff from the area upstream of this lake was routed through the Upper Lake Minnie Ha-Ha.

It was determined that the existing spillways for the upper and lower lakes are capable of passing the outflow resulting from the 1 percent chance (100-year frequency) flood without overtopping the dams.

According to the Corps of Engineers, the estimated length of the flood damage zone, should failure of the Upper Lake Minnie Ha-Ha Dam occur, extends three miles downstream. This damage zone is based on the premise that flow over the crest of the lower lake dam would occur and continue downstream. The effect of failure of the lower lake dam due to failure of the upper lake dam has not been investigated. Within the possible damage zone are Lower Lake Minnie Ha-Ha, five dwellings, including three in the Town of Minnith, and two county road bridges. The estimated length of the flood damage zone for the Lower Lake Minnie Ha-Ha Dam extends approximately one mile downstream of the dam. Within the possible damage zone are five dwellings, including three in the Town of Minnith.

A review of available data did not disclose that seepage or stability analyses of these dams were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies and safety defects reported herein.

Harold B. Lockett

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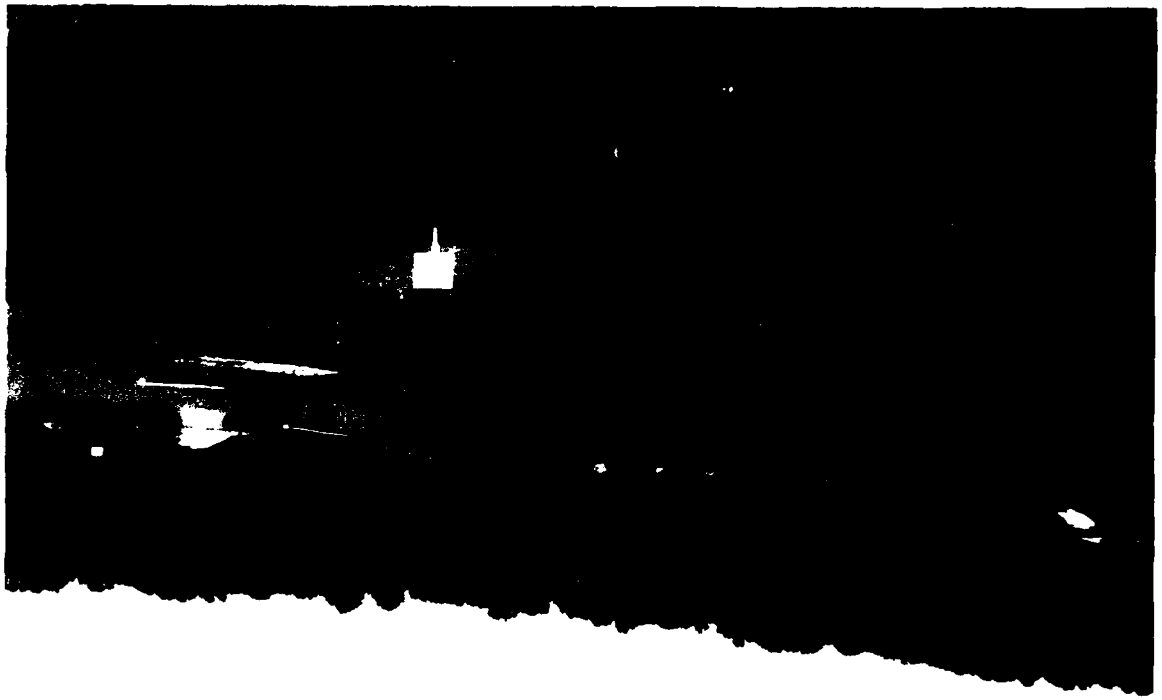
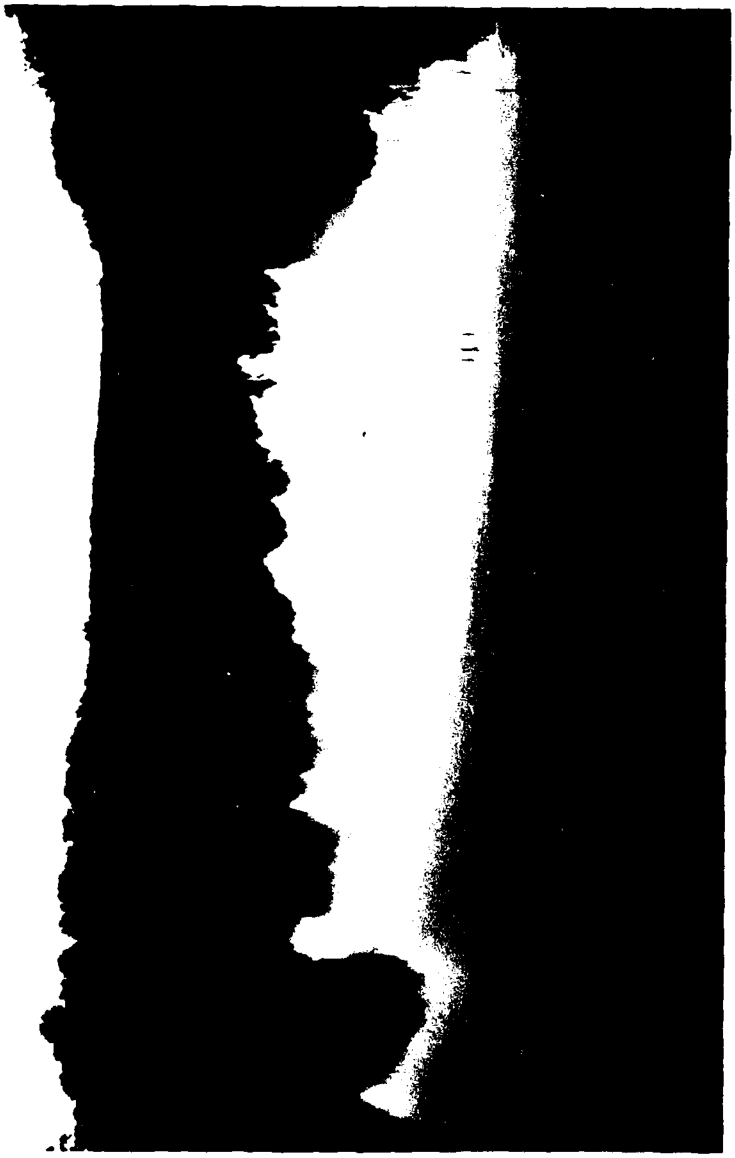
P.E. Missouri E-4189

Albert B. Becker, Jr.

Albert B. Becker, Jr.
P.E. Missouri E-9138





PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

UPPER LAKE MINNIE HA-HA DAM - ID. NO. 30643
LOWER LAKE MINNIE HA-HA DAM - ID. NO. 30644

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

UPPER LAKE MINNIE HA-HA DAM - ID NO. 30643

LOWER LAKE MINNIE HA-HA DAM - ID NO. 30644

SECTION I - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Upper and Lower Lake Minnie Ha-Ha Dams be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of each of the above dams with respect to safety and, based upon available data and this inspection, determine if either of these dams poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Dams," dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. General. Upper and Lower Lakes Minnie Ha-Ha are recreational lakes located approximately 1 mile northwest of Minnith, Missouri. The

location of the lakes is shown on the Regional Vicinity Map, Plate 1. As indicated on Plate 2, the lakes are located in tandem fashion along an unnamed tributary of Saline Creek with the lower lake abutting the upstream lake dam.

b. Description of Dams and Appurtenances.

(1) Upper Lake Minnie Ha-Ha Dam. The Upper Lake Minnie Ha-Ha Dam is an earthfill type embankment rising approximately 39 feet above the original streambed. The embankment has an upstream slope (above the waterline) of 1v on 2.3h, a crest width of about 14 feet, and an irregular downstream slope that varies from 1v on 1.4h to 1v on 2.7h. A 9-foot wide berm is located near the downstream toe. The length of the dam including the spillway section is approximately 694 feet. A road surfaced with gravel traverses the dam crest. A plan and profile of the dam is shown on Plate 3 and a cross section of the dam is shown on Plate 4.

The spillway, a broad-crested trapezoidal weir section, is located at the east or left abutment of the dam. The road traversing the dam crest crosses the spillway crest. The spillway discharge channel directs flow away from the downstream face of the dam. A berm that serves to protect tne embankment is provided between the channel and the downstream face of the dam. The upper portion of the spillway discharge channel, a grass lined trapezoidal section, is cut into the hillside to an intersection with a ravine that in turn flows into Lower Lake Minnie Ha-Ha. The lower reach of the excavated channel adjacent to the ravine is steep and deeply eroded to bedrock. Old tires and discarded machinery have been placed in the lower areas of the channel in an attempt to control further erosion. A profile of the spillway discharge channel is shown on Plate 4.

At normal pool elevation, Upper Lake Minne Ha-Ha occupies approximately 18 acres. There are no drawdown facilities provided for the Upper Lake.

(2) Lower Lake Minnie Ha-Ha Dam. The Lower Lake Minnie Ha-Ha Dam is an earthfill type embankment rising approximately 27 feet above the original streambed. The embankment has an upstream slope (above the waterline) of 1v on 3.9h, a crest width of about 12 feet, and a downstream slope of about 1v on 3h. The length of the dam including the spillway is approximately 426 feet. A plan and profile of the dam is shown on Plate 5 and a cross-section of the dam is shown on Plate 6.

The spillway, a broad-crested trapezoidal weir section, is located at the east or left abutment of the dam. The spillway discharge channel, a grass lined trapezoidal section, conducts flow away from the dam. The channel is cut into the hillside with a protective berm between the channel and the downstream face of the dam. The discharge channel extends downstream to an intersection with a ravine that joins the original stream channel. The lower portion of the spillway channel adjacent to the ravine is steep, and rock riprap has been provided at this location to control erosion. A profile of the discharge channel is shown on Plate 6.

At normal pool elevation, Lower Lake Minnie Ha-Ha occupies approximately 6 acres. A 3-inch pipe with a control valve at the outlet end is provided to unwater the lower lake. The pipe passes through the dam emerging on the downstream side at the toe of slope.

c. Location. The Upper and Lower Lake Minnie Ha-Ha Dams are located in Section 20, Township 36 North, Range 9 East, of Ste. Genevieve County, Missouri. The dams lie within a development known as Lake Minnie Ha-Ha, Inc., the entrance to which is located on Minnith Road about 1 mile northwest of County Road N, just east of Minnith, Missouri, as shown on the Regional Vicinity Map, Plate 1.

d. Size Classification. The size classifications of these dams, based on the height of each dam and its storage capacity, and categorized according to Table I, "Recommended Guidelines for Safety Inspection of Dams," are small.

e. Hazard Classification. The Upper Lake Minnie Ha-Ha Dam and the Lower Lake Minnie Ha-Ha Dam, according to the St. Louis District, Corps of Engineers, have a high hazard potential. A high hazard classification means that the dam is located where failure may cause loss of life, serious damage to homes, extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. According to the Corps of Engineers, the estimated length of the flood damage zone, should failure of the Upper Lake Minnie Ha-Ha Dam occur, extends three miles downstream. This damage zone is based on the premise that flow over the crest of the lower lake dam would occur and continue downstream. The effect of failure of the lower lake dam due to failure of the upper lake dam has not been investigated. Within the possible damage zone are the lower lake and dam, five dwellings, including three in the Town of Minnith, and two county road bridges. The estimated length of the flood damage zone for the Lower Lake Minnie Ha-Ha Dam extends approximately one mile downstream of the dam. Within the possible damage zone are five dwellings, including three in the Town of Minnith.

f. Ownership. The lakes and dams are owned by Lake Minnie Ha-Ha, Inc., a Missouri Corporation. The current president of the corporation is Mr. Ralph R. Rodenmeyer, 5 Linn, Ste. Genevieve, Missouri 63670.

g. Purpose of Dams. The dams impounds water for the purpose of recreation by the members of the corporation.

h. Design and Construction History. According to Mr. Donald J. Heil, the former owner and developer of the property, the Upper Lake Minnie Ha-Ha Dam was constructed in 1963, and the Lower Lake Minnie Ha-Ha Dam was constructed in about 1969 by the Gegg Construction Company of Ste. Genevieve, Missouri. Some assistance was provided by Mr. Ed Herman, of the Agriculture Department of Stabilization and Conservation Office, Ste. Genevieve, Missouri. Mr. James H. Williams, of the Missouri Geological Survey, visited the site and also advised Mr. Heil prior to construction.

i. Normal Operational Procedures. The lake levels are unregulated.

1.3 PERTINENT DATA

a. Drainage Areas. Immediately surrounding the Upper Lake Minnie Ha-Ha the land use is residential. For the lower lake , and for the upland areas tributary to the upper lake, the land use is predominantly pasture, or unimproved and wooded. The watershed area above Upper Lake Minnie Ha-Ha amounts to approximately 256 acres. The watershed area above Lower Lake Minnie Ha-Ha amounts to approximately 282 acres. The watershed areas are outlined on Plate 2.

b. Discharge at Dam Site:

(1) Upper Lake Minnie Ha-Ha Dam:

(a) Estimated known maximum flood at damsite ... 230 cfs*

(b) Spillway capacity ... 300 cfs (W.S. Elev. 496.4)

(2) Lower Lake Minnie Ha-Ha Dam:

(a) Estimated known maximum flood at damsite ... No data available

(b) Spillway capacity ... 950 cfs (W.S. Elev. 471.5)

c. Elevation (ft. above MSL). The following elevations were determined by survey and are based on topographic data shown on an advanced copy of the 1980 USGS Weingarten SE, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Upper Lake Minnie Ha-Ha Dam:

(a) Top of dam ... 496.4 (min.)

(b) Normal pool (spillway crest) ... 494.0

(c) Streambed at centerline of dam ... 459±

(d) Maximum observed tailwater ... No data available

(e) Tailwater at time of inspection ... 465.9 (W.S. lower lake)

*Based on an estimate of depth of flow at spillway per former owner.

(2) Lower Lake Minnie Ha-Ha Dam:

(a) Top of dam ... 471.5 (min.)

(b) Normal pool (spillway crest) ... 468.0

(c) Streambed at centerline of dam ... 445±

(d) Maximum observed tailwater ... No data available

d. Reservoir.

(1) Upper Lake Minnie Ha-Ha:

(a) Length at normal pool (Elev. 494.0) ... 1,750 ft.

(b) Length at maximum pool (Elev. 496.4) ... 1,900 ft.

(2) Lower Lake Minnie Ha-Ha:

(a) Length at normal pool (Elev. 468.0) ... 700 ft.

(b) Length at maximum pool (Elev. 471.5) ... 710 ft.

e. Storage.

(1) Upper Lake Minnie Ha-Ha Dam:

(a) Normal pool ... 393 ac. ft.

(b) Top of dam (incremental) ... 47 ac. ft.

(2) Lower Lake Minnie Ha-Ha Dam:

(a) Normal pool ... 53 ac. ft

(b) Top of dam (incremental) ... 24 ac. ft.

f. Reservoir Surface.

(1) Upper Lake Minnie Ha-Ha Dam:

(a) Normal pool ... 18 acres

(b) Top of dam (incremental) ... 2 acres

(2) Lower Lake Minnie Ha-Ha Dam:

(a) Normal pool ... 6 acres

(b) Top of dam (incremental) ... 1 acre

g. Dam.

(1) Upper Lake Minnie Ha-Ha Dam:

(a) Type ... Earthfill, homogeneous*

(b) Length ... 694 ft.

*Per former owner

(c) Height ... 39 ft.

(d) Top width ... 14 ft.

(e) Side slopes

1. Upstream ... 1v on 2.3 h (above waterline)

2. Downstream ... Irregular, 1v on 1.4h to 1v on 2.7h

(f) Cutoff ... Core trench*

(g) Slope protection

1. Upstream ... Stone riprap

2. Downstream ... Grass

(2) Lower Lake Minnie Ha-Ha Dam:

(a) Type ... Earthfill, homogeneous*

(b) Length ... 426 ft.

(c) Height ... 27 ft.

(d) Top width ... 12 ft.

(e) Side slopes

1. Upstream ... 1v on 3.9h (above waterline)

2. Downstream ... 1v on 3h

(f) Cutoff ... Core trench*

(g) Slope protection

1. Upstream ... Grass

2. Downstream ... Grass

h. Spillway.

(1) Upper Lake Minnie Ha-Ha Dam:

(a) Type ... Uncontrolled, broad-crested trapezoidal earth weir

(b) Elevation ... 494.0 (Ft. above MSL)

(c) Approach channel ... Lake

(d) Discharge channel ... Grass lined trapezoidal section in earth cut. Lower reach eroded to rock

(2) Lower Lake Minnie Ha-Ha Dam:

(a) Type ... Uncontrolled, broad-crested, trapezoidal earth weir

(b) Elevation ... 468.0 (Ft. above MSL)

(c) Approach channel ... Lake

*Per former owner

(d) Discharge channel ... Grass lined trapezoidal section in earth cut

i. Outlet for Lake Drawdown.

(1) Upper Lake Minnie Ha-Ha Dam ... None

(2) Lower Lake Minnie Ha-Ha Dam ... 3-inch pipe with valve

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

As far as can be determined, detailed hydrologic/hydraulic, seepage, or stability analyses for the two dams were not performed.

A report containing the results and recommendations of an investigation of the proposed Upper Lake Minnie Ha-Ha site performed by Mr. J.H. Williams and Mr. J.A. Martin of the Missouri Geological Survey (MGS) in 1962 and a letter from Mr. J.H. Williams, Engineering Geologist, MGS, are presented on Charts 2-1 through 2-4. In the report it is pointed out that the bedrock exposed in the reservoir area is Roubidoux sandstone with interbedded dolomite layers and chert beds and that the bedrock is jointed or fractured at nearly every rock outcropping that was examined. It is also noted that water loss within the reservoir area can be expected through the open joints and along bedding planes in the bedrock, and that it may be necessary to grout the bedrock to insure a minimum water loss.

2.2 CONSTRUCTION

No formal records were maintained during construction of the dams. Interviews with Mr. Donald J. Heil, the former owner, and Mr. H.F. Gegg, of the Gegg Construction Company, builder of the dams, indicated that core trenches, approximately 10 feet wide, were excavated to sound rock for both dams, and that the material used to backfill the trenches was mixed with bentonite in order to reduce lake seepage. The material used to construct the embankments, a stoney red clay, was obtained from the area to be occupied by the lakes and to some extent the adjacent hillsides. The fill was compacted with the earthmoving equipment used to haul the fill.

2.3 OPERATION

According to Mr. Heil, in 1978 seepage was observed in the downstream face of the Upper Lake Minnie Ha-Ha Dam near the right abutment. In order to seal the leak several truck loads of lime were placed at selected locations along the upstream face of the dam. According to the former owner, this measure effectively halted the seepage that was occurring at this location.

The water level in each lake is uncontrolled and governed by the crest elevations of the excavated earthen spillways. Emergency spillways are not provided.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dams and spillways was not available.

b. Adequacy. No design data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Upper and Lower Lake Minnie Ha-Ha Dams was made by Horner & Shifrin engineering personnel, A.B. Becker, Civil and Soils Engineer, H.B Lockett, Civil Engineer and Hydrologist, and T.K. Deddens, Geological Engineer, on 19 September 1979. An examination of the dam sites was also made by an engineering geologist, Jerry D. Higgins, a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection was the area below the dams within the potential flood damage zone. Photographs of the dams taken at the time of the inspection are included on Pages A-1 through A-7 of Appendix A. Locations of the inspection photographs are indicated on Plates 3 and 5.

b. Area Geology. The dam sites are located on the northeastern flank of the Ozark Uplift on gently dipping (eastward) Ordovician age sedimentary rock. The uniform bedrock structure is intersected by the east-west trending Ste. Geneieve Fault system which passes within 2 miles to the north of the dam sites. Rather than a single fault, the Ste. Genevieve system is formed by a number of roughly parallel faults forming numerous horsts and grabens. In the general area of the lakes, Ordovician age Roubidoux and Jefferson City formations are exposed at the surface. The Roubidoux consists of interbedded sandstone, dolomitic sandstone, and cherty dolomite. The sandstone is composed of fine-to-medium-grained quartz sand, varying in color from gray to brown on weathered surfaces and light yellow, tan or red on a fresh surface. The dolomite is light gray to brown, thinly to thickly bedded, and finely crystalline. Dolomite beds commonly contain brown to gray, banded oolitic chert, brecciated chert, or cryptozoan (reef) chert. The Jefferson City formation is composed of light brown to brown, medium to finely crystalline dolomite and argillaceous dolomite.

The dams and lakes are founded on dolomite, sandstone and residuum of the Roubidoux formation. The residuum derived from in situ weathering, is a cherty, sometimes sandy, red to brown clay, and often is somewhat more permeable than normal clays. The upland around the reservoirs consists of residuum and dolomite of the Jefferson City formation. The residuum is a tan to brown cherty clay which drapes over the Roubidoux residuum on hillsides.

Occasional exposures of Roubidoux dolomites and sandstones are present around both reservoirs and in the abutments. Good exposures are also present in the spillway on the left abutment of Upper Lake Minnie Ha-Ha Dam. The remaining reservoir area is covered by thin Roubidoux residuum.

The Ste. Genevieve Fault system does not cross the dam sites; however, the Ste. Genevieve Seismotectonic Region has been the center of several significant historic seismic events. An event of Modified Mercalli Intensity of VII may occur in this region based upon the postulated recurrence of historic earthquake events. Based upon the site geology and distance from the fault system, the most likely seismic hazard would be due to ground motion rather than ground failure by faulting in the event of an earthquake.

c. <u>Dams.</u>

(1) <u>Upper Lake Minnie Ha-Ha Dam.</u> The visible portions of the upstream and downstream faces of the dam (See Photos 1 and 2) appeared generally to be in sound condition. A hole, believed to be an animal burrow (see Photo 8) was noticed at the downstream toe of slope about 120 feet from the right abutment, with consequent erosion (about 0.8 foot deep) above the hole. An erosion ditch approximately 3 feet deep has developed in the hillside about 15 feet downstream of the right abutment. Stone riprap, average 18-inch dimension, with some larger, is provided along the waterline at the upstream face. Above the riprap on the upstream face there are several areas of dense brush and grass, about 2 feet high.

No surface cracks or misalignment of the dam crest was evident and the gravel surfaced road traversing the dam crest appeared to be in good condition. The downstream face of the dam was covered with dense brush, small trees, and grass that was about 3 feet high at the time of the inspection.

Seepage, estimated at less than 1 gpm, was observed emerging from the downstream face of the dam (see Photo 7) about 10 feet above the lower lake near the right abutment.

The gravel covered crest section of the earth spillway (see Photo [illegible]) appeared to be in good condition, without signs of erosion. A line of metal fence posts without fence fabric (see Photo 3) crosses the spillway approach channel from the lake. The upper reach of the spillway discharge channel, a grass covered trapezoidal section excavated in the hillside (see Photo 5) was found to be in good condition. The lower reach of the outlet channel is steep and has been eroded (see Photo 6) to the underlying bedrock. Old tires and discarded machinery have been placed in this portion of the channel presumably in an attempt to control further erosion. The outlet channel flows into a natural draw which in turn joins Lower Lake Minnie Ha-Ha about 400 feet below the upper lake dam.

(2) <u>Lower Lake Minnie Ha-Ha Dam.</u> The visible portions of the upstream and downstream faces of the dam (see Photos 9 and 10) appeared to be in satisfactory condition although the plant cover on the crest and the downstream face of the dam was in an unkept condition with high, about 3 feet, grass, dense brush and numerous small trees. Minor erosion at the waterline of the unprotected upstream face that appeared to be due to wave action was noticed. Above the eroded area the grass on the upstream face was about 2.5 feet high. No cracking or misalignment of the dam crest was evident.

The valve at the outlet end of the 3-inch lake drawdown pipe (see Photo 13) was exposed near the toe of slope and appeared to be in operating condition. However, the valve operating handle had been removed.

Just below the right side of the dam and extending across an area approximately 75 feet wide, a marshy condition exists. Standing water (see Photo 14), soft ground, and cattails were found through this area. Collected seepage from this area was estimated to be flowing at a rate of about 5 gpm.

The earth crest section of the spillway at the left abutment appeared to be in fair condition (see Photo 11); however, erosion has created a pilot channel that extends along the entire crest. The upper reach of the discharge channel, a grass covered trapezoidal section excavated into the hillside, was found to be in good condition. The lower portion of the outlet channel is steep and appeared to be eroded to bedrock. Stone riprap (see Photo 12) has been placed at the upper end of the section to help control erosion. The outlet channel flows into a natural draw which in turn joins the downstream channel.

d. Downstream Channel. The downstream channel, an unnamed tributary of Saline Creek, located below the Lower Lake Minnie Ha-Ha Dam is unimproved. The tributary joins Saline Creek at a point about 0.5 mile below the lower lake.

e. Reservoir.

(1) Upper Lake Minnie Ha-Ha. The lake is part of a private recreation area, with a portion of the area adjacent to the lake occupied by mobile homes and other small buildings. The upland areas of the watershed are undeveloped and in a natural, wooded condition. At the time of the inspection, the lake was clear, with no apparent sedimentation.

(2) Lower Lake Minnie Ha-Ha. The area surrounding the lake is undeveloped and in a natural, wooded condition. At the time of the inspection, the lake was clear, with no apparent sedimentation.

3.2 EVALUATION

The deficiencies observed during the inspection and noted herein as well as in Section 7, paragraph 7.2b, are not considered of major consequence to warrant immediate remedial action.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway for each dam is uncontrolled. The water surface levels for the lakes are governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled spillways. The level of the lower lake is also affected by spillway releases of the upper lake.

4.2 MAINTAINANCE OF DAMS

Based on the unkept condition and extensive cover of small trees, brush and high grass on both dams, it is evident that these areas receive little attention. It also appears that there is a lack of concern for problems related to seepage at the Lower Lake Minnie Ha-Ha Dam since there have been no provisions made to control the seepage flow and/or drain the affected areas. It was noted that some attempt has been made to control erosion in the lower reaches of the spillway discharge channels by placing old tires and stone riprap in the eroded areas.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

With the exception of the 3-inch valve on the drawdown pipe for the lower lake, no outlet operating facilities exist at these dams.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of dam failure warning systems.

4.5 EVALUATION

Lack of or inadequate maintainance is considered detrimental to the safety of a dam. It is recommended that maintainance of each dam be undertaken on a regular basis, and that records be kept of all maintainance performed. It is also recommended that some means be provided to alleviate the problems associated with seepage including control of the seepage flow and drainage of the affected areas.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area for each lake were developed from an advanced copy of the 1980 USGS Weingarten, SE, Missouri, Quadrangle Map. The proportions and dimensions of the spillways and dams were developed from surveys made during the inspection.

c. Visual Observations.

(1) Upper Lake Minnie Ha-Ha Dam:

(a) The spillway consists of an approximate trapezoidal section with a 30-foot wide bottom width and side slopes of about 1v on 2h on the left side and about 1v on 1.5h on the right side.

(b) The spillway is located within the embankment at the left abutment.

(c) The spillway outlet channel has approximately the same cross sectional area as the spillway. The channel follows a course at a nearly flat slope away from the dam for about 250 feet before falling abruptly into a natural draw which in turn flows into Lower Lake Minnie Ha-Ha. Near the centerline of the channel about 200 feet from the dam, past spillway flows have cut a narrow (8 feet wide) V-shaped channel to the underlying stepped and jagged rock surface. Old tires and machinery have been placed in this section in an attempt to curtail further erosion.

The spillway channel conducts flow away from the embankment, therefore, spillway discharges will not endanager the integrity of the dam. Spillway discharges enter Lower Lake Minnie Ha-Ha from the left (east) near the center of the lake.

(d) No emergency spillway is provided.

(e) No lake drawdown facilities are provided.

(2) Lower Lake Minnie Ha-Ha Dam.

(a) The spillway consists of an approximate trapezodial section with a 40-foot wide bottom and slopes of about 1v on 4h on the left side and about 1v on 2h on the right side.

(b) The spillway is located within the embankment at the left abutment.

(c) The spillway outlet channel has approximately the same cross sectional area as the spillway. The channel follows a course at a nearly flat slope away from the dam for about 100 feet before falling abruptly into a natural draw which in turn flows into the stream that joins Saline Creek about one-half mile below the dam. The spillway conducts flow away from the embankment, therefore, spillway discharges will not endanger the integrity of the dam.

(d) No emergency spillway is provided.

(e) A 3-inch pipe with a control valve at the downstream end is provided to dewater the lake.

d. Overtopping Potential.

(1) Upper Lake Minnie Ha-Ha Dam. The spillway is inadequate to pass the probable maximum flood or 1/2 the probable maximum flood without overtopping the dam. It is adequate, however, to pass the 1 percent chance (100-year frequency) flood without overtopping the dam. The results of a dam overtopping analysis are as follows:

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth of Flow Over Dam (Elev. 496.4)	Duration of Overtopping of Dam (Hrs.)
0.17	300	496.4	0.0	0.0
0.5	2,301	497.8	1.4	4.7
1.0	5,000	498.6	2.2	7.0
100-Yr. Flood	223	496.1	0.0	0.0

Elevation 496.4 was found to be the low point in the dam crest. The flow safely passing the spillway just prior to overtopping was determined to be 300 cfs, which amounts to 17 percent of the probable maximum flood inflow. This outflow is greater than the outflow from the 1 percent chance (100-year frequency) flood. During peak flow of the probable maximum flood, the greatest depth of flow over the dam would be 2.2 feet with the overflow extending the entire length of the dam crest.

(2) Lower Lake Minnie Ha-Ha Dam. The spillway is inadequate to pass the probable maximum flood or the 1/2 probable maximum flood without overtopping the dam. It is adequate, however, to pass the 1 percent chance (100-year frequency) flood without overtopping the dam. The results of a dam overtopping analysis are as follows:

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth of Flow Over Dam (Elev. 471.5)	Duration of Overtopping of Dam (Hrs.)
0.31	950	471.5	0.0	0.0
0.5	2,198	473.0	1.5	0.7
1.0	5,375	474.6	3.1	3.1
100-Yr. Flood	211	496.6	0.0	0.0

The inflow hydrograph used in the overtopping analysis includes the outflow from the Upper Lake Minnie Ha-Ha. In the analysis it was assumed that the upstream dam had not failed even though overtopping of the dam had occurred.

Elevation 471.5 was found to be the low point in the dam crest. The flow safely passing the spillway just prior to overtopping was determined to be 950 cfs, which amounts to 31 percent of the probable maximum flood inflow. This outflow is greater than the outflow from 1 percent chance (100-year frequency) flood. During peak flow of the probable maximum flood, the greatest depth of flow over the dam would be 3.1 feet with the overflow extending the entire length of the dam crest.

e. Evaluation.

Inspection of the existing spillway channels indicated that the material (a gravelly, yellow to brown clay) can, under certain conditions such as high velocity flow, be very erodible. An examination of the dams indicated that the material used to construct these embankments is similar to that observed in the spillway channel. For the PMF condition where the depth of flow overtopping each dam and the duration of flow over each dam are appreciable (maximum of 2.2 feet for 7.0 hours at the upper lake dam and a maximum of 3.1 feet for 3.1 hours at the lower lake dam), damage to the downstream faces of these dams is expected. The extent of these damages is not predictable; however, it is likely, considering the erosion that has occurred in the spillway channels, that they could result in failure of these dams.

f. References. Procedures, data, and watershed characteristics for the two lakes are presented on pages B-1 and B-2. Results of routing the probable maximum flood at ratios reflecting the capacity of the upper lake are presented on page B-3 of Appendix B. Procedures, data, and results of routing the probable maximum flood through the upper and lower lakes of ratios indicative of the capacity of the lower lake and overtopping of the upper lake are presented on pages B-4 and B-5. Procedures, data, and results of routing the 1 percent chance (100-year frequency) flood through the upper and lower lake are presented on pages B-6 through B-8. Probable maximum flood hydrographs for the upper and lower lake are presented on pages B-9 and B-10. Area-Storage curves for the upper and lower lakes are presented on Plates 11 and 13, respectively. Spillway discharge rating curves for the upper and lower lakes are presented on Plates 12 and 14, respectively.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations which adversely affect the structural stability of the dams are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. Construction data relating to the structural stability of these dams were not available for review. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. With the exception of the valve on the drawdown pipe for the lower lake, no appurtenant structures or facilities requiring operation exist at these dams. According to the former owner, no records are kept of lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Charges. According to the former owner, with the exception of sealing the embankment near the right abutment of the upper lake with lime in 1978, no post construction changes have been made which would affect the structural stability of the dams.

e. Seismic Stability. As indicated in Section 3, paragraph 3.1b, an earthquake of Modified Mercalli Intensity VII may occur in this region based upon the postulated recurrence of historic earthquake events. However, based upon site geology and distance from the fault system, the most likely seismic hazard would be the result of induced ground motion, rather than ground failure by faulting. Therefore, and considering the

fact that the dams are located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to these dams, provided that static stability conditions are satisfactory and conventional safety margins exist.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety.

(1) Overtopping.

(a) Upper Lake Minnie Ha-Ha Dam. A hydraulic analysis indicates that the existing spillway is capable of passing lake outflow of about 300 cfs without the level of the lake exceeding the lowest point of the dam. A hydrologic analysis of the runoff from the lake watershed area indicated that, for a storm of probable maximum flood magnitude, the lake outflow would be on the order of 5,000 cfs, and that for the one percent chance (100-year frequency) flood, the lake outflow would be approximately 220 cfs.

(b) Lower Lake Minnie Ha-Ha Dam. A hydraulic analysis indicates that the spillway is capable of passing lake outflow of about 950 cfs without the level of the lake exceeding the lowest point of the dam. A hydrologic analysis of the runoff from the lake watershed area indicated that, for a storm of probable maximum flood magnitude, the lake outflow would be on the order of 5,370 cfs, and that for the one percent chance (100-year frequency) flood, the lake outflow would be approximately 210 cfs.

(2) Visual Observations. Several items were noticed during the visual inspection that may affect the safety of these dams. These items are seepage, erosion, animal burrows, and small trees and brush that exist on the faces of the dams. The extent and locations of these items are discussed in Section 3.

(3) Seepage and Stability Analyses. Seepage and stability analyses of these dams were not available for review and therefore, no judgement could be made with respect to the structural stability of these dams.

b. Adequacy of Information. Due to lack of engineering and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessment of the hydrology of the watersheds and capacities of the spillways were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analysis comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The items concerning the safety of the dams noted in paragraph 7.1a and the remedial measures recommended in paragraphs 7.2 should be accomplished within a reasonable period of time.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. As indicated in Section 3, paragraph 3.1b,an earthquake of Modified Mercalli Intensify VII may occur in this region based upon the postulated recurrence of historic earthquake events. However, based upon site geology and the distance from the fault system, the most likely seismic hazard would be the result of induced ground motion, rather than ground failure by faulting. Therefore, and considering the fact that the dams are located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dams, provided that static stability conditions are satisfactory and conventional safety margins exist.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Based upon criteria set forth in the recommended guidelines, alterations to the design of both dams should be made in order to pass lake outflows resulting from a storm of probable maximum flood magnitude.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses (comparable to the requirements of the guidelines, in order to determine the structural stability of the dams for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of dams.

b. Operations and Maintainance (O & M) Procedures. The following O & M procedures, applicable to each dam unless otherwise indicated, are recommended:

(1) Remove the trees and brush that may conceal animal burrows from the faces of the dams. Animal burrows and tree roots can provide a passageway for seepage that could lead to a piping (progressive internal erosion) condition and potential failure of the dams. Trees should be removed under the guidance of an engineer experienced in the design and construction of earthen dams, since indiscriminate clearing could jeopardize the safety of the dams. The existing turf cover should be restored if destroyed or missing. Maintain plant cover on all embankments at a height that will not hinder inspection of the dam or provide cover for burrowing animals.

(2) The existing animal burrow and eroded area at the toe of slope on the downstream face of the Upper Lake Minnie Ha-Ha Dam at the right abutment should be filled with earth and the surface restored.

(3) Provide some means of preventing piping due to uncontrolled seepage at the downstream faces of the dams. A piping condition can result in failure of the dam.

(4) Provide some form of protection (other than grass) at the upstream face of the lower lake dam in order to prevent erosion of the embankment by wave action or fluctuating lake levels. Erosion of the embankment could result in loss of section that could impair the stability of the dam.

(5) Provide maintainance of all areas of the dams and spillways on a regularly scheduled basis in order to ensure that these features are maintained in a satisfactory condition.

(6) A detailed inspection of the dam should be instituted on a regularly scheduled basis by a qualified engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.

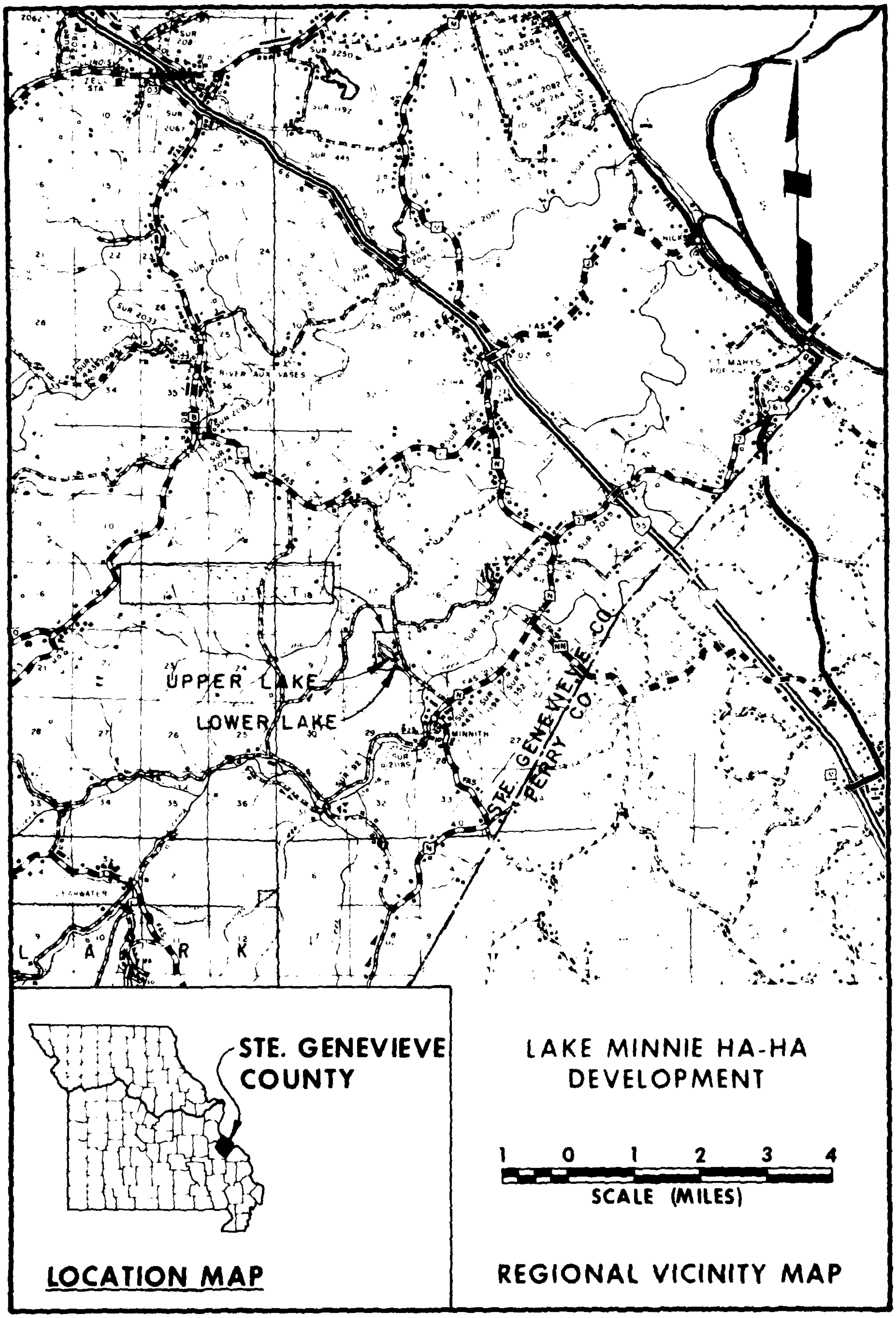
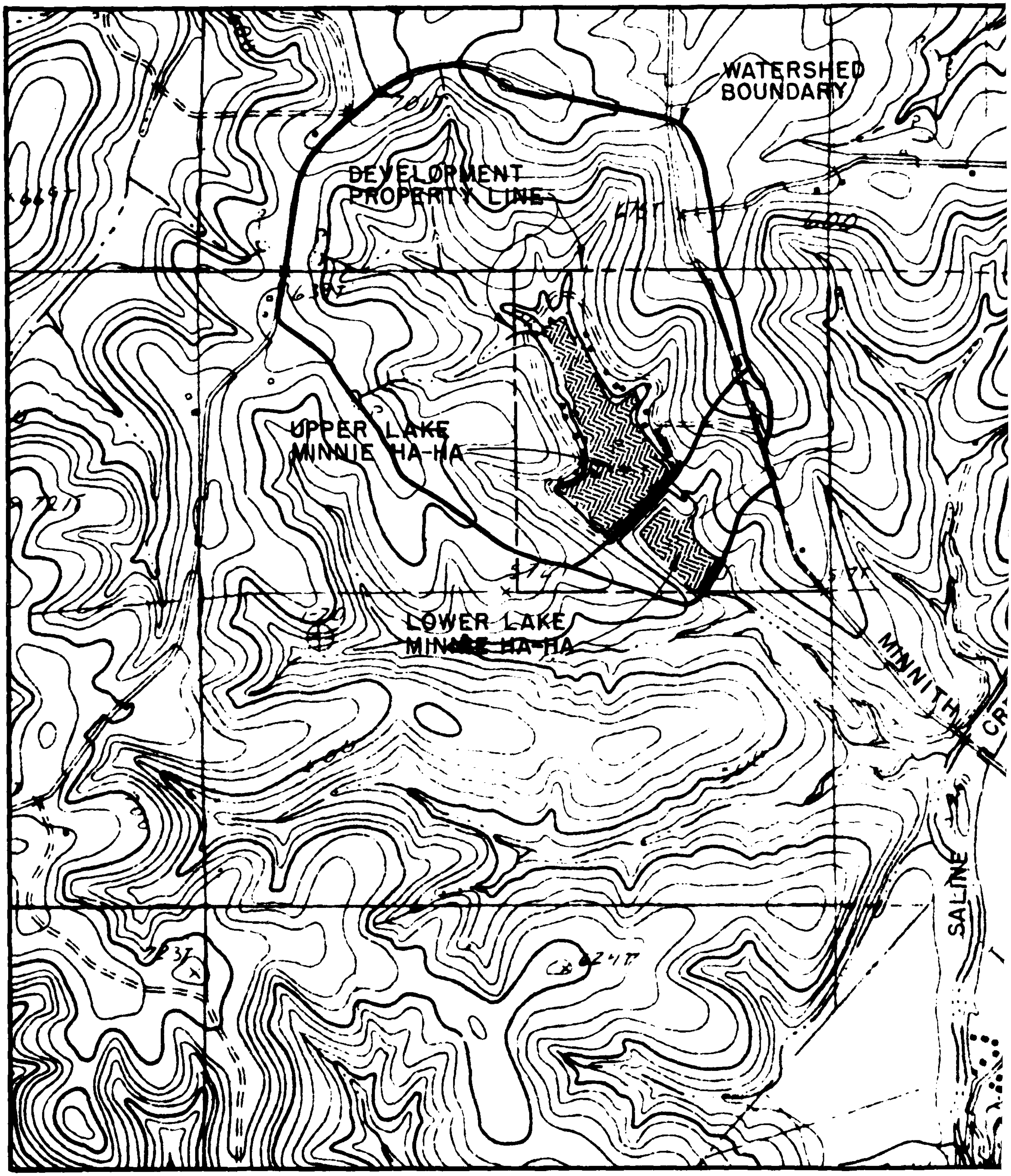
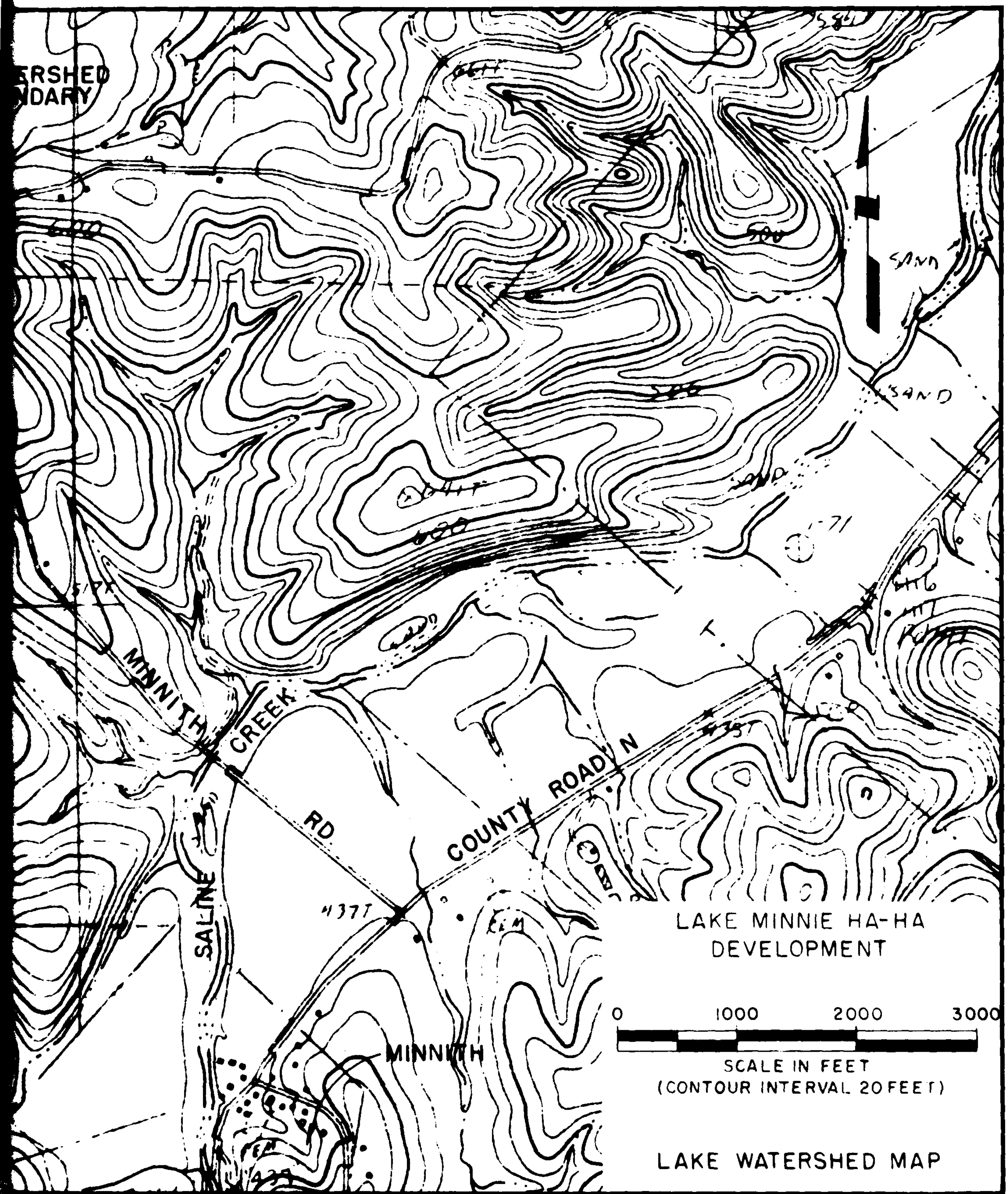

UPPER LAKE
LOWER LAKE
MINNITH
RIVER AUX VASES
ST. MARYS
STE. GENEVIEVE CO.
PERRY CO.
STE. GENEVIEVE
COUNTY
LOCATION MAP
LAKE MINNIE HA-HA
DEVELOPMENT
1 0 1 2 3 4
SCALE (MILES)
REGIONAL VICINITY MAP

PLATE 1


WATERSHED
BOUNDARY
DEVELOPMENT
PROPERTY LINE
UPPER LAKE
MINNIE HA-HA
LOWER LAKE
MINNIE HA-HA
MINNITH
SALINE
CR



ERSHED
NDARY
MINNITH CREEK
RD
COUNTY ROAD N
SALINE
MINNITH
SAND
LAKE MINNIE HA-HA
DEVELOPMENT
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP

12

PLATE 2

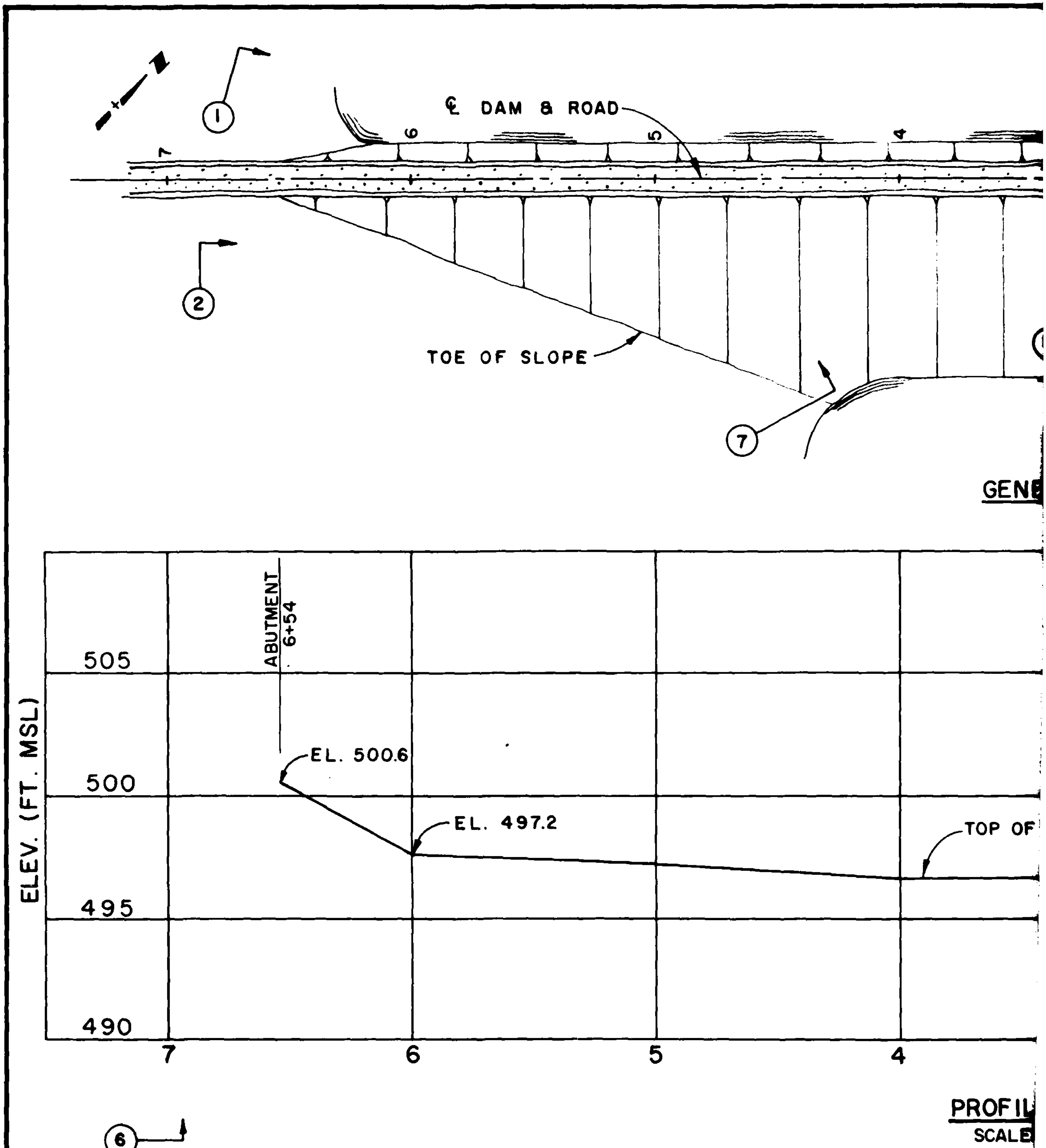
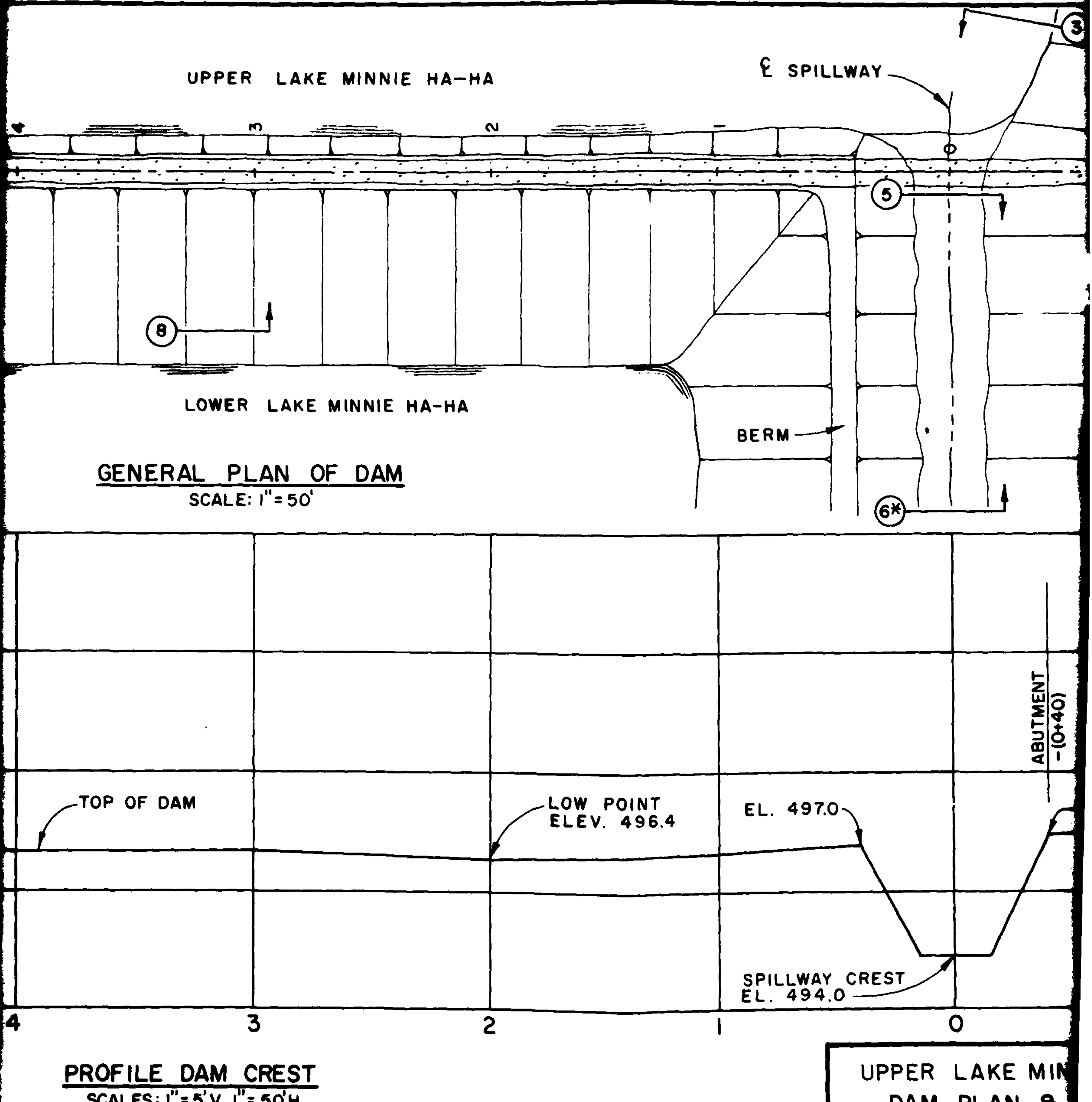


PHOTO LOCATION & KEY
(SEE APPENDIX A)

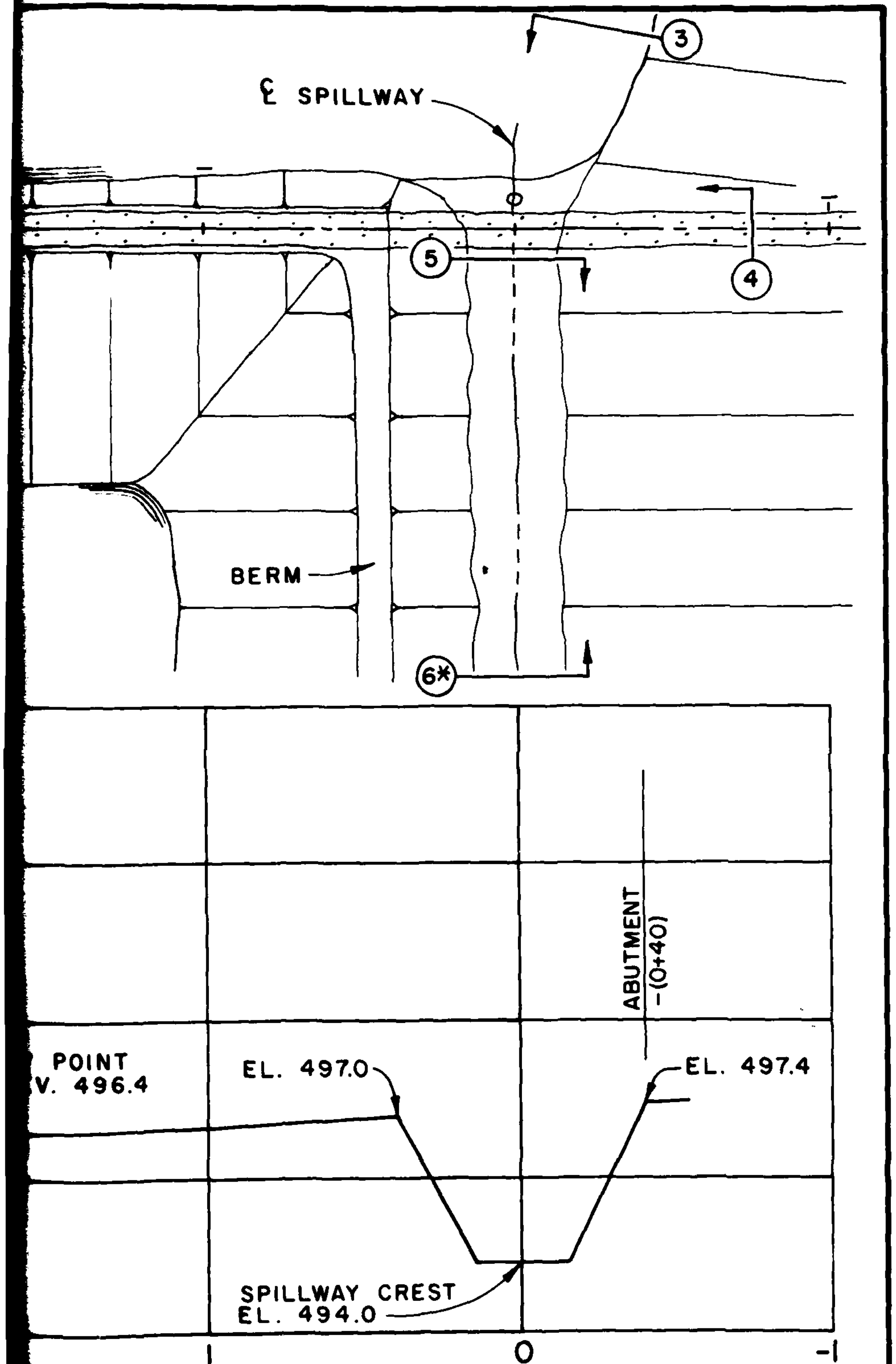
*ACTUAL LOCATION APPROX.
300 FT. BELOW DAM



UPPER LAKE MIN
DAM PLAN &

Horner & Shifrin, Inc.

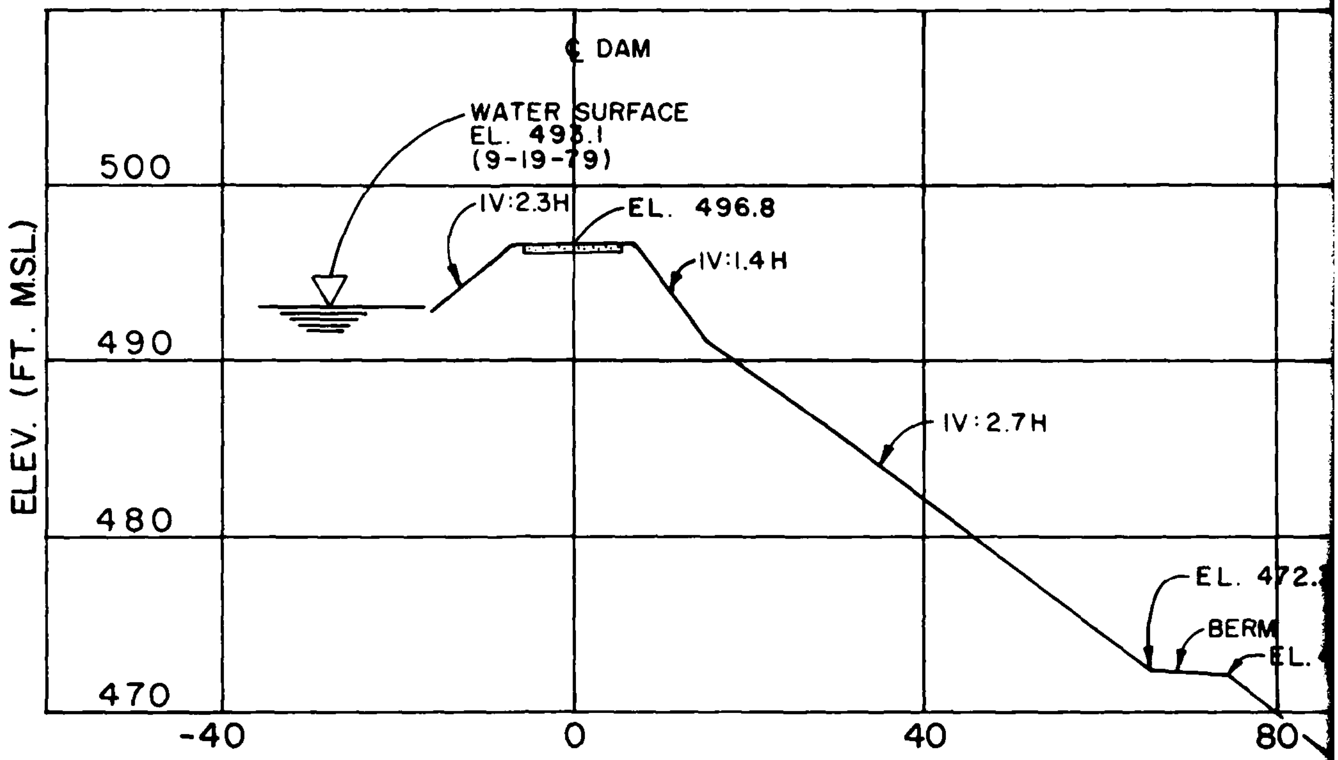
12



UPPER LAKE MINNIE HA-HA
DAM PLAN & PROFILE

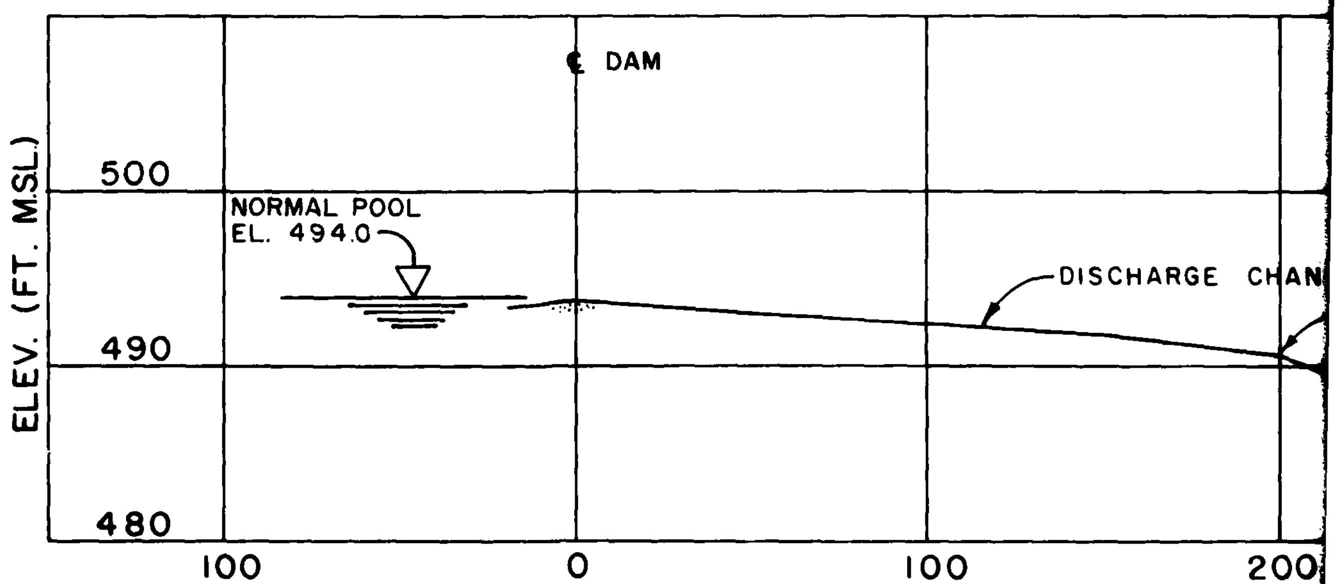
Horner & Shifrin, Inc. Oct. 1979

13 PLATE 3



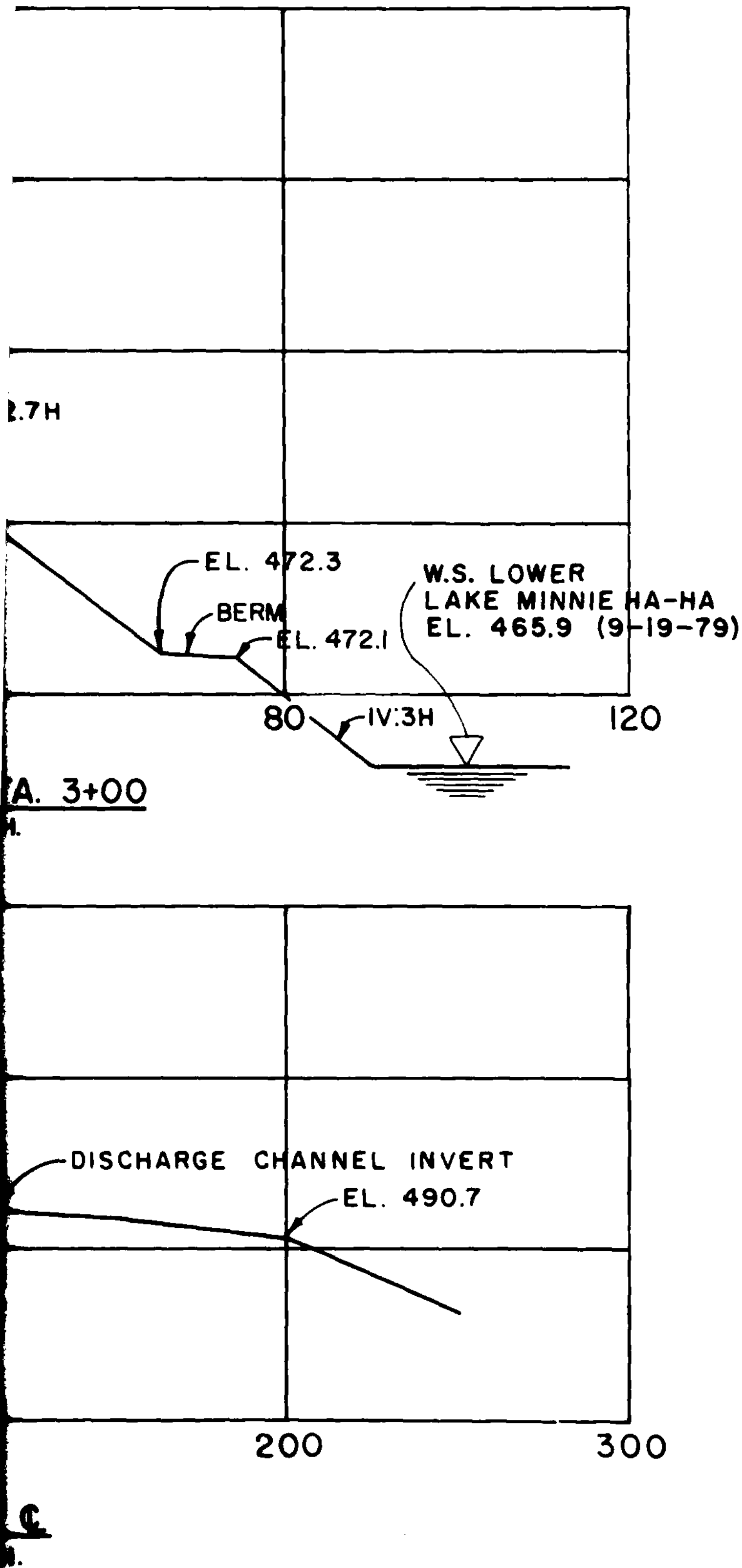
DAM CROSS SECTION STA. 3+00

SCALES 1"=10' V., 1"=20' H.



PROFILE SPILLWAY ℄

SCALES: 1"=10'V., 1"=50 H.

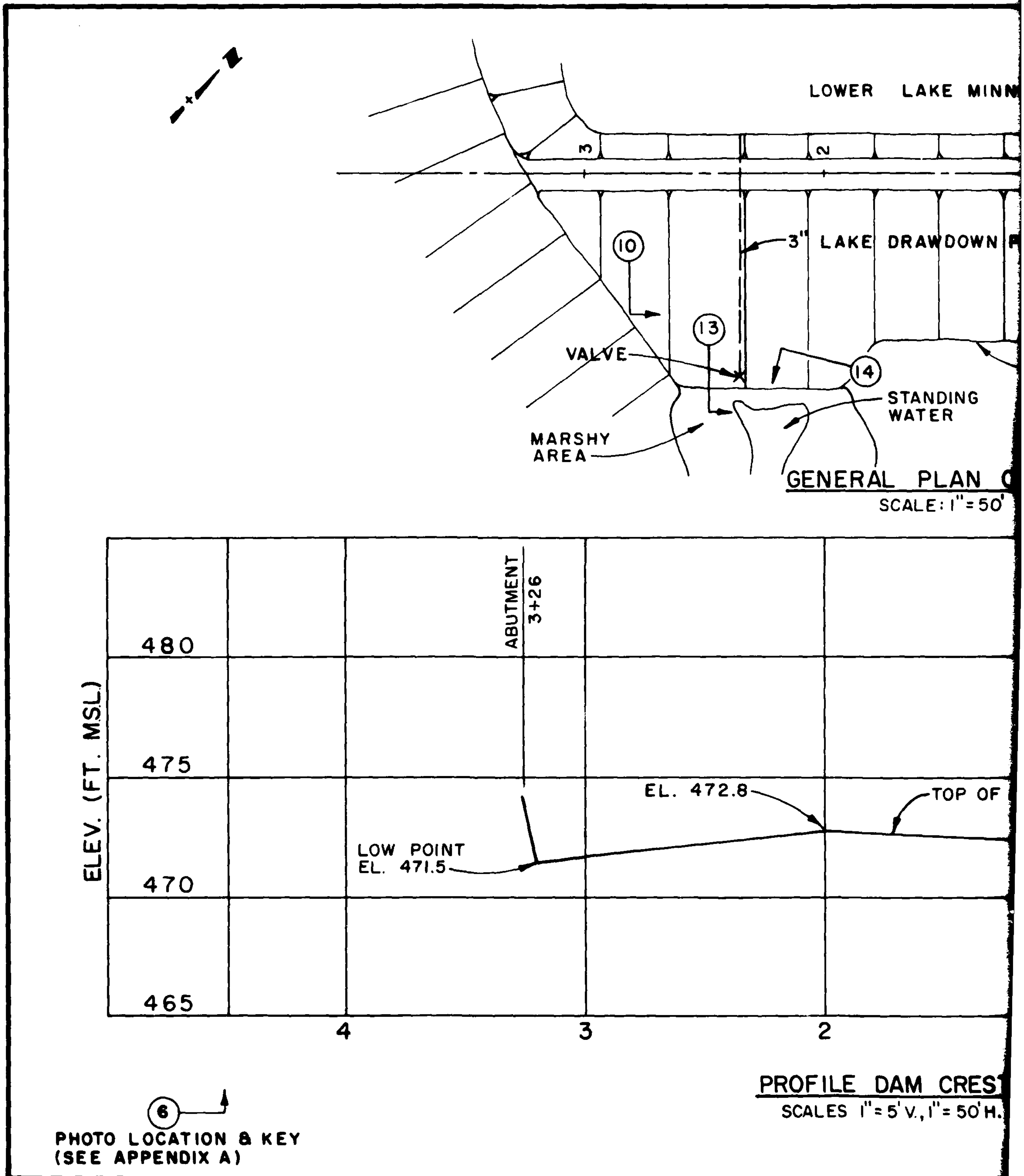


UPPER LAKE MINNIE HA-HA
DAM CROSS-SECTION &
SPILLWAY PROFILE

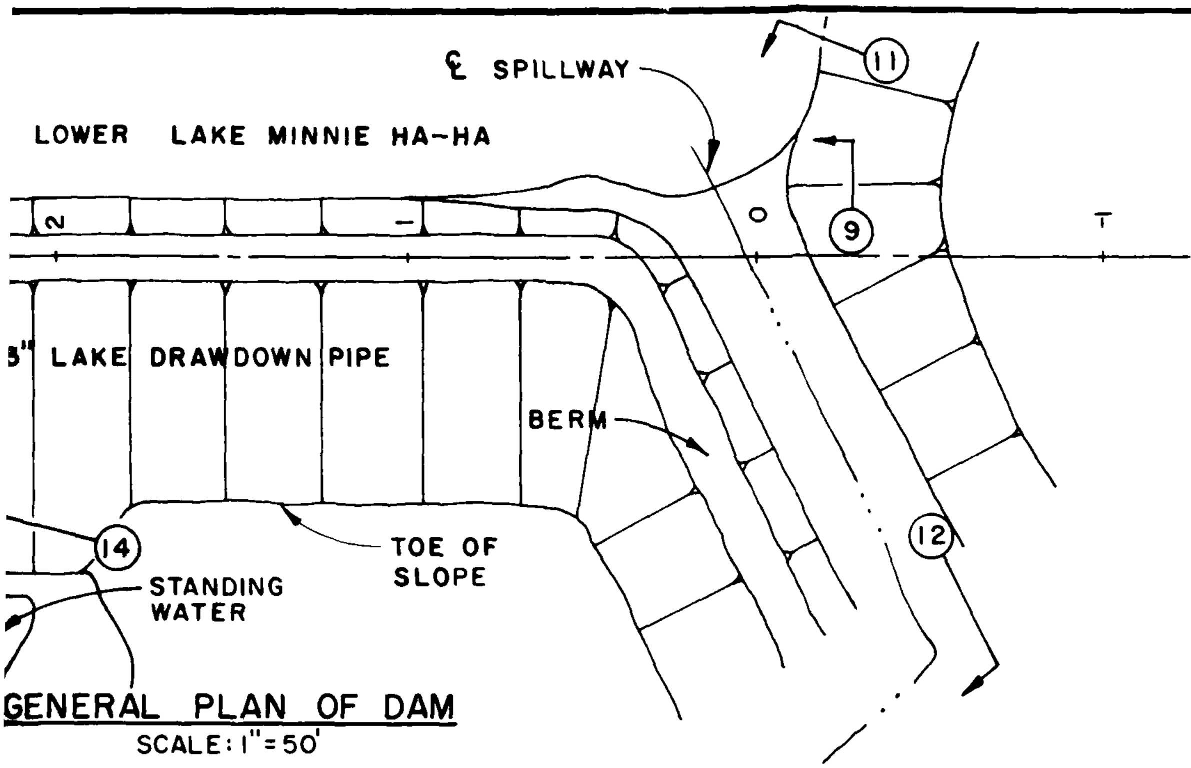
Horner & Shifrin, Inc. Oct. 1979

12

PLATE 4

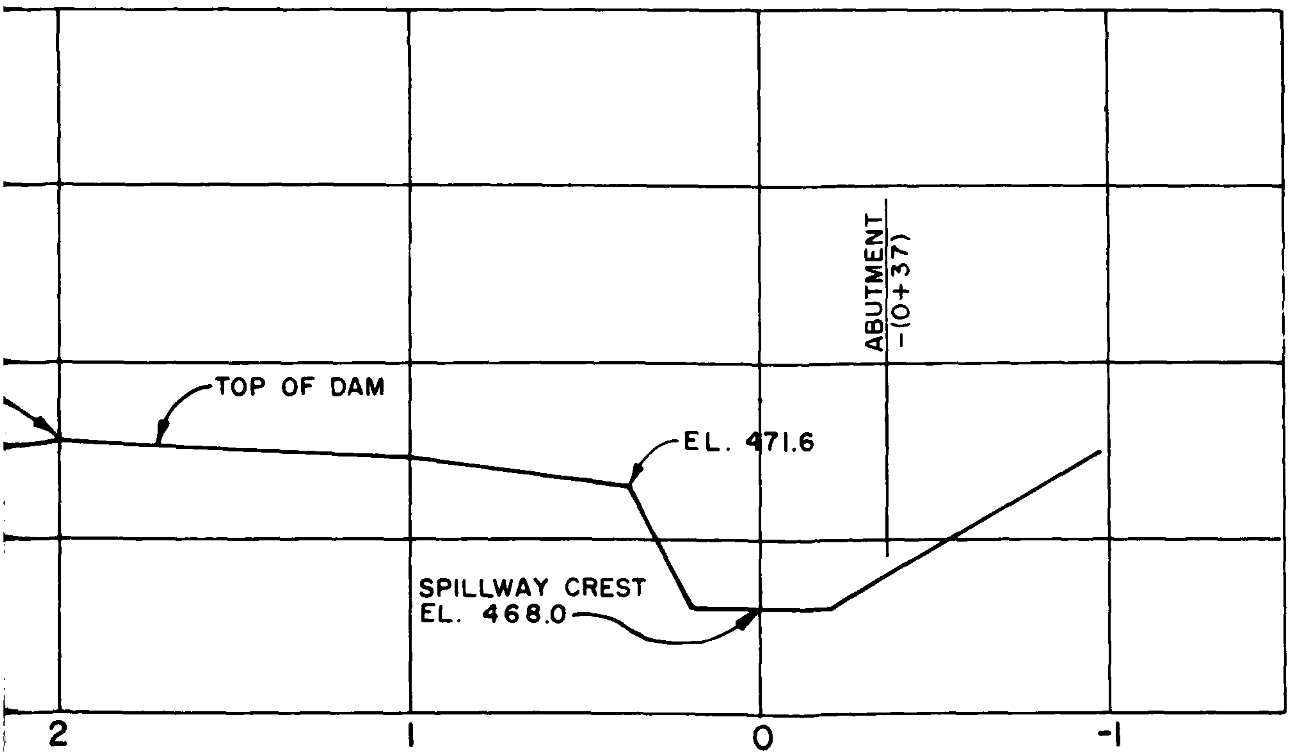


LOWER LAKE MINN
3
2
3" LAKE DRAWDOWN P
10
13
14
VALVE
STANDING WATER
MARSHY AREA
GENERAL PLAN O
SCALE: 1" = 50'
ABUTMENT 3+26
480
475
470
465
ELEV. (FT. MSL.)
EL. 472.8
TOP OF
LOW POINT EL. 471.5
4
3
2
PROFILE DAM CREST
SCALES 1" = 5' V., 1" = 50' H.
6
PHOTO LOCATION & KEY
(SEE APPENDIX A)



GENERAL PLAN OF DAM

SCALE: 1" = 50'



OFILE DAM CREST

CALES 1" = 5' V., 1" = 50' H.

LOWER LAKE MINNIE HA-HA
DAM PLAN & PROFILE

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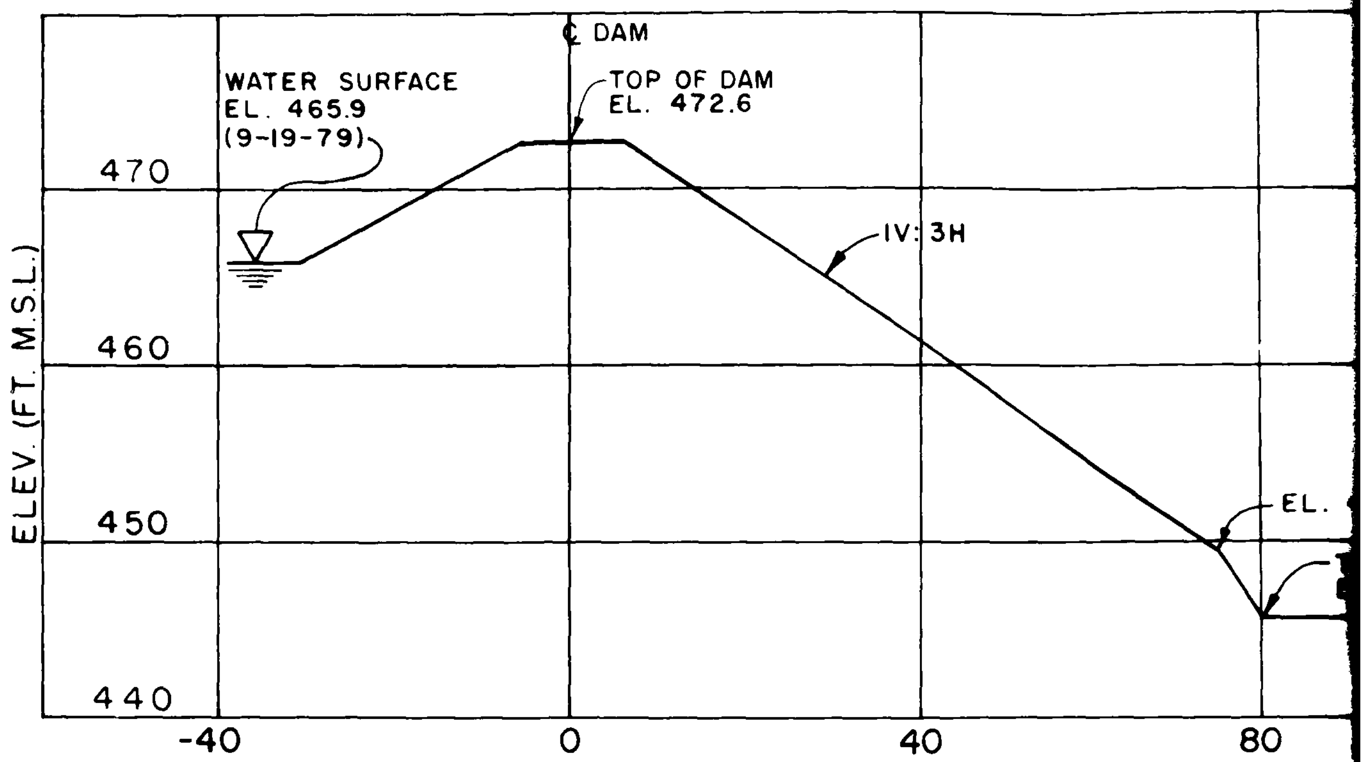
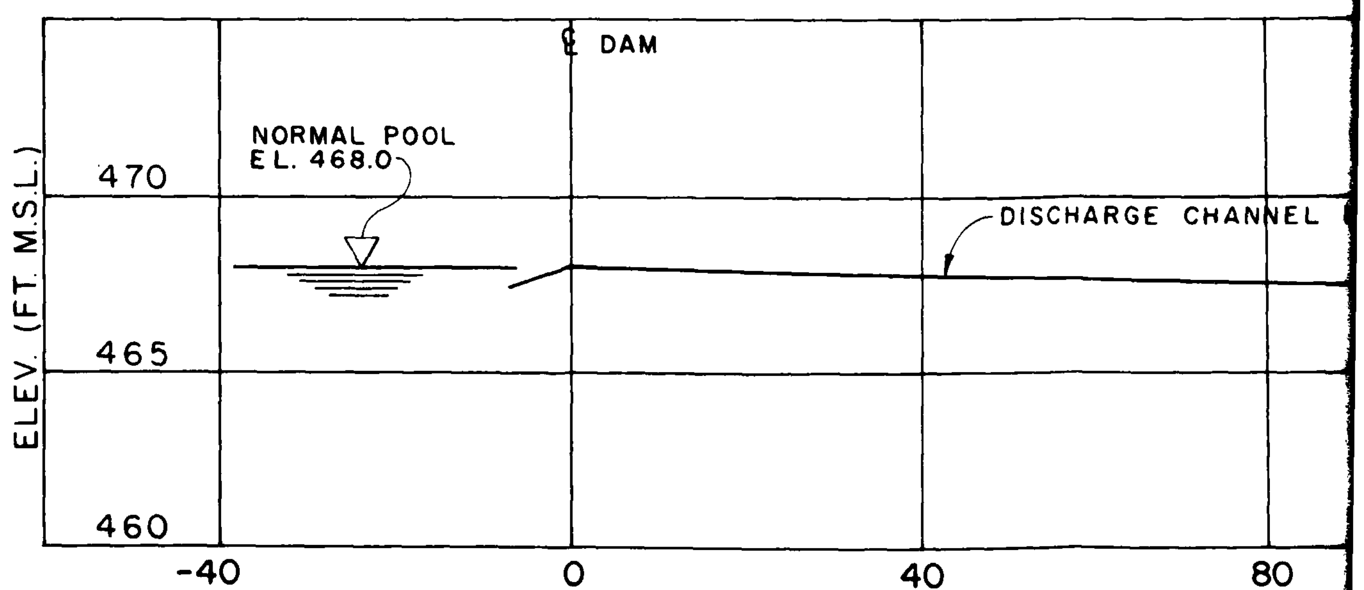
PLATE 5



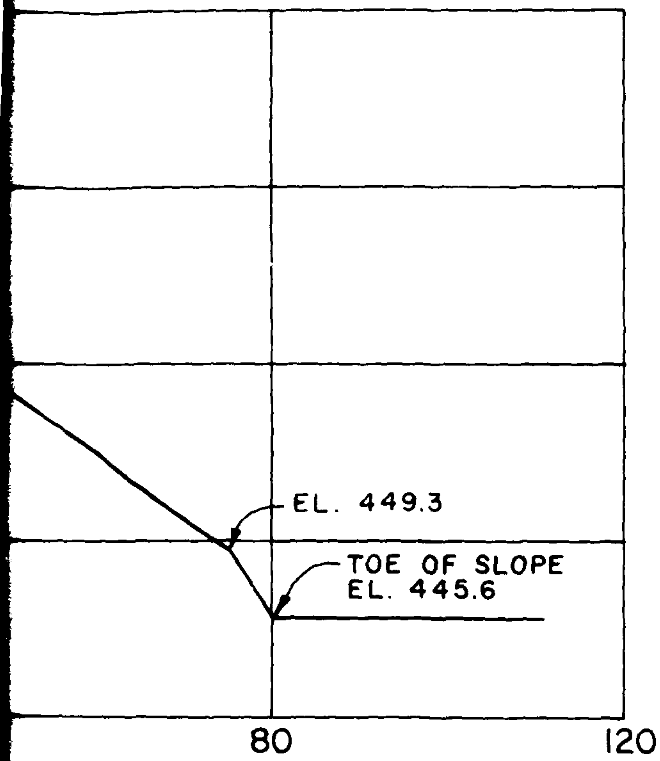
DAM CROSS SECTION STA. 2+30

SCALES 1"=10' V., 1"=20' H.

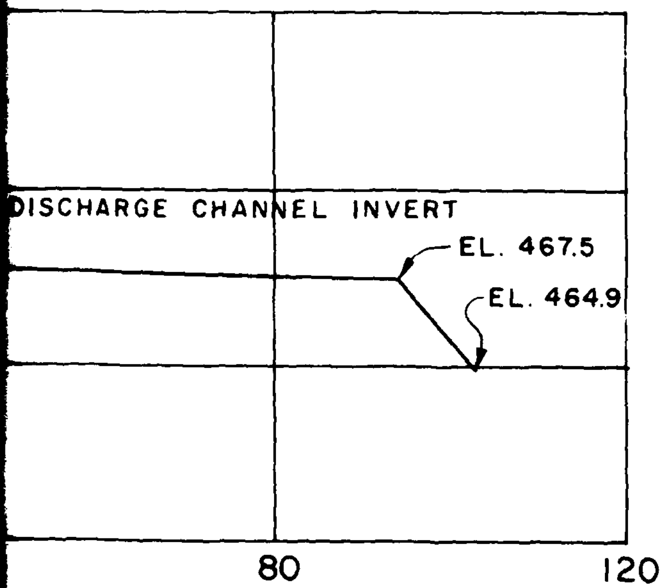


PROFILE SPILLWAY ℄

SCALES: 1"=5' V., 1"=20' H.



. 2+30

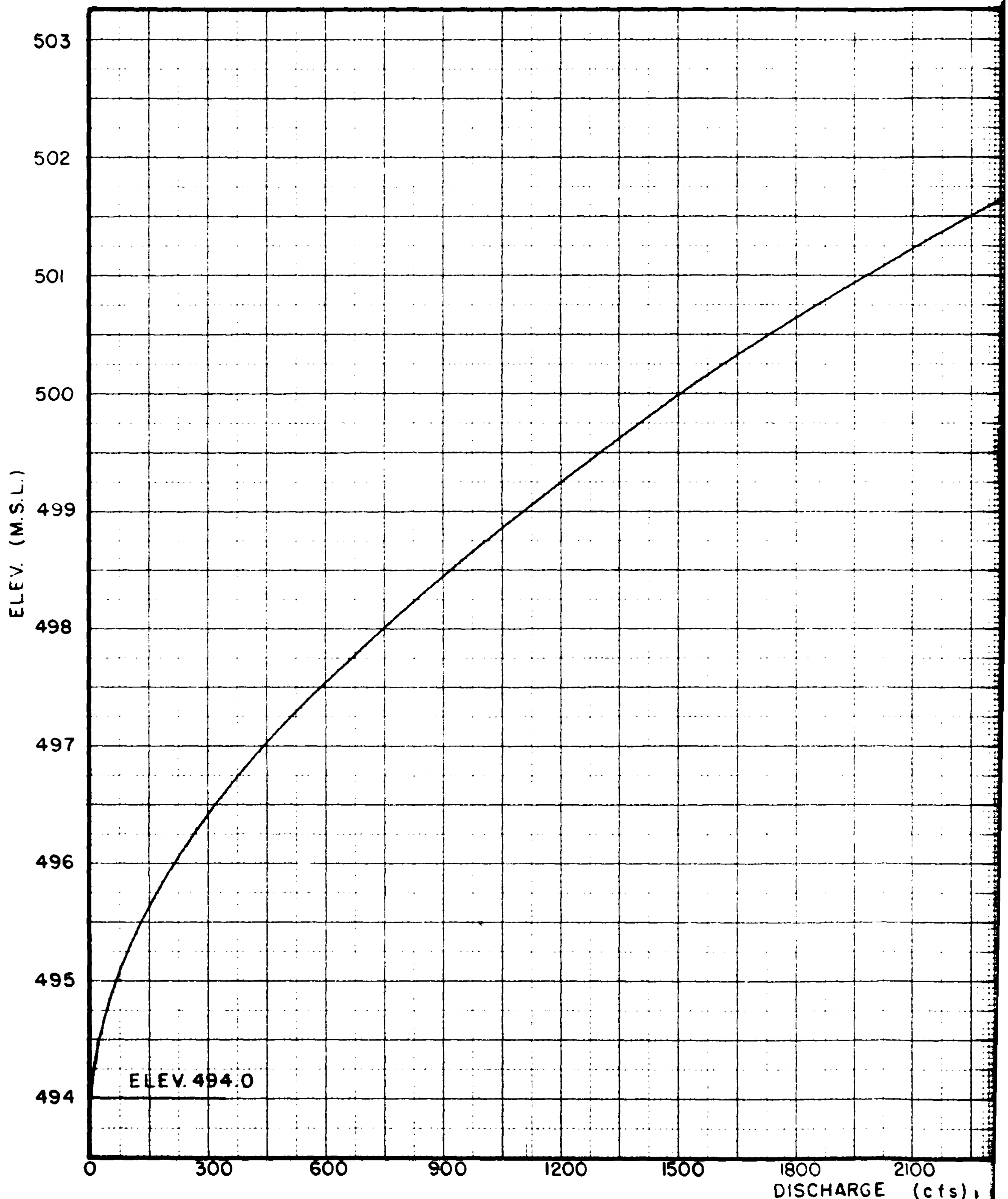


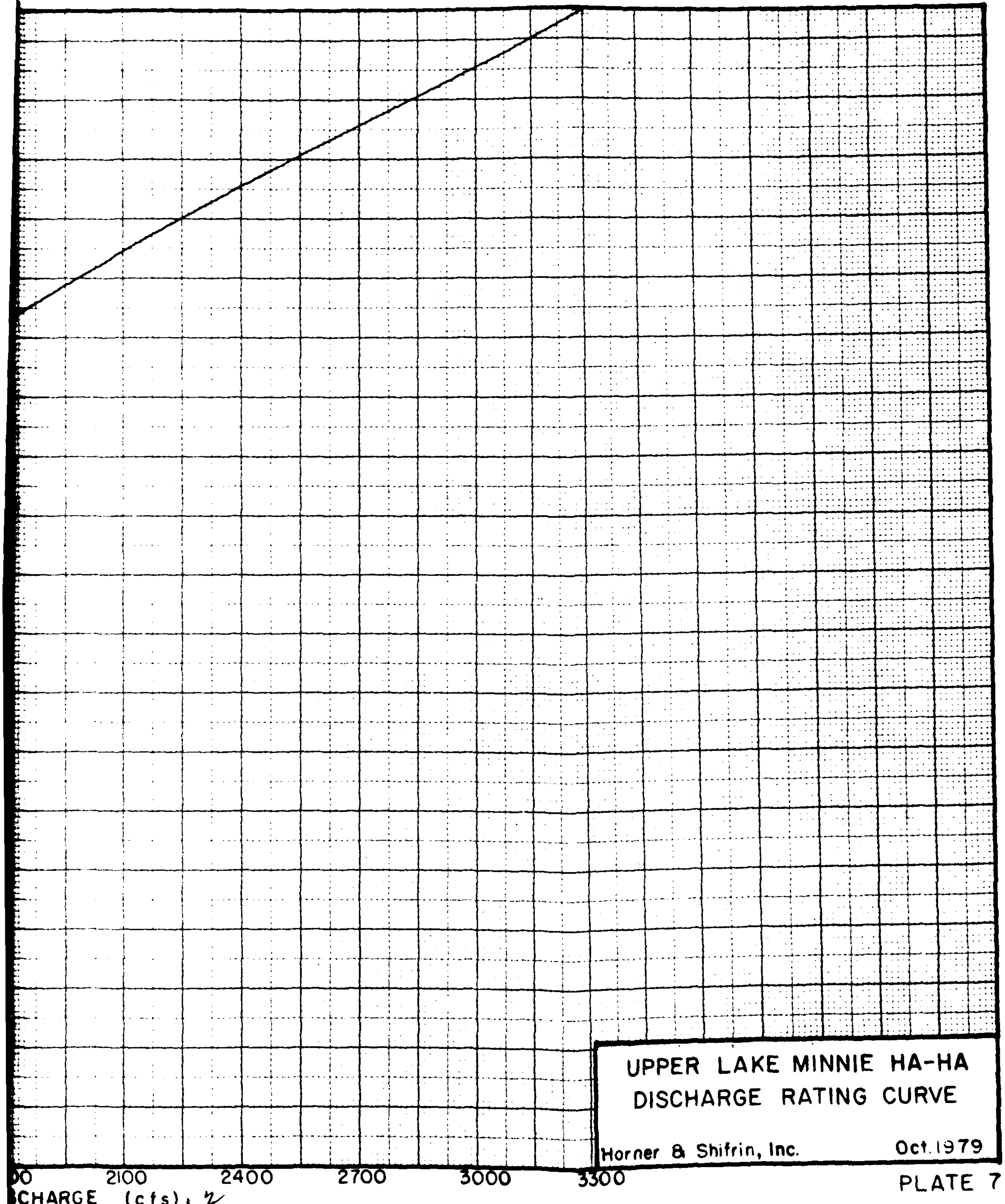
C

LOWER LAKE MINNIE HA-HA
DAM CROSS-SECTION &
SPILLWAY PROFILE
Horner & Shifrin, Inc. Oct. 1979

12

PLATE 6


503
502
501
500
499
498
497
496
495
494
ELEV. (M.S.L.)
ELEV. 494.0
0
300
600
900
1200
1500
1800
2100
DISCHARGE (cfs)



UPPER LAKE MINNIE HA-HA
DISCHARGE RATING CURVE

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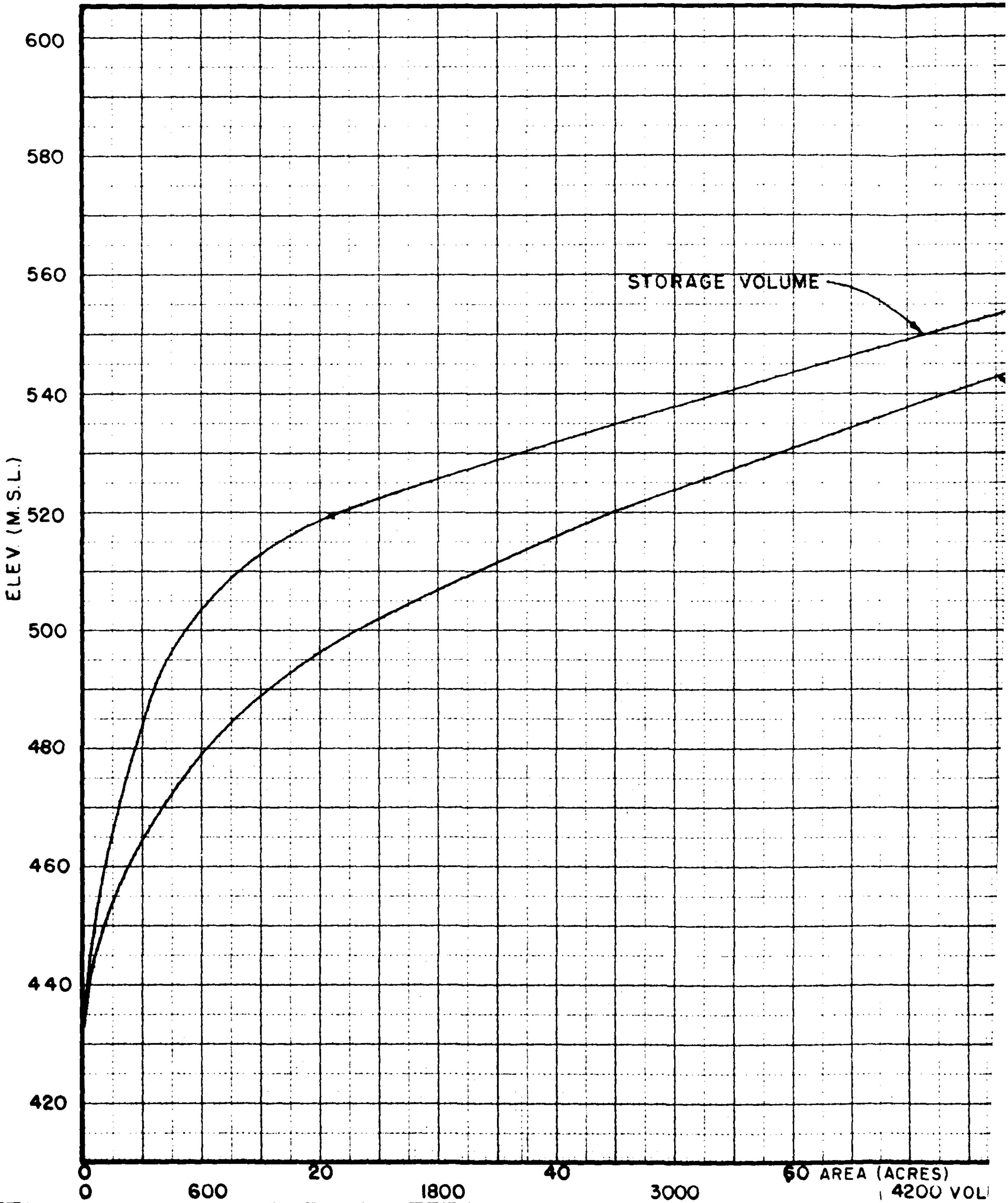
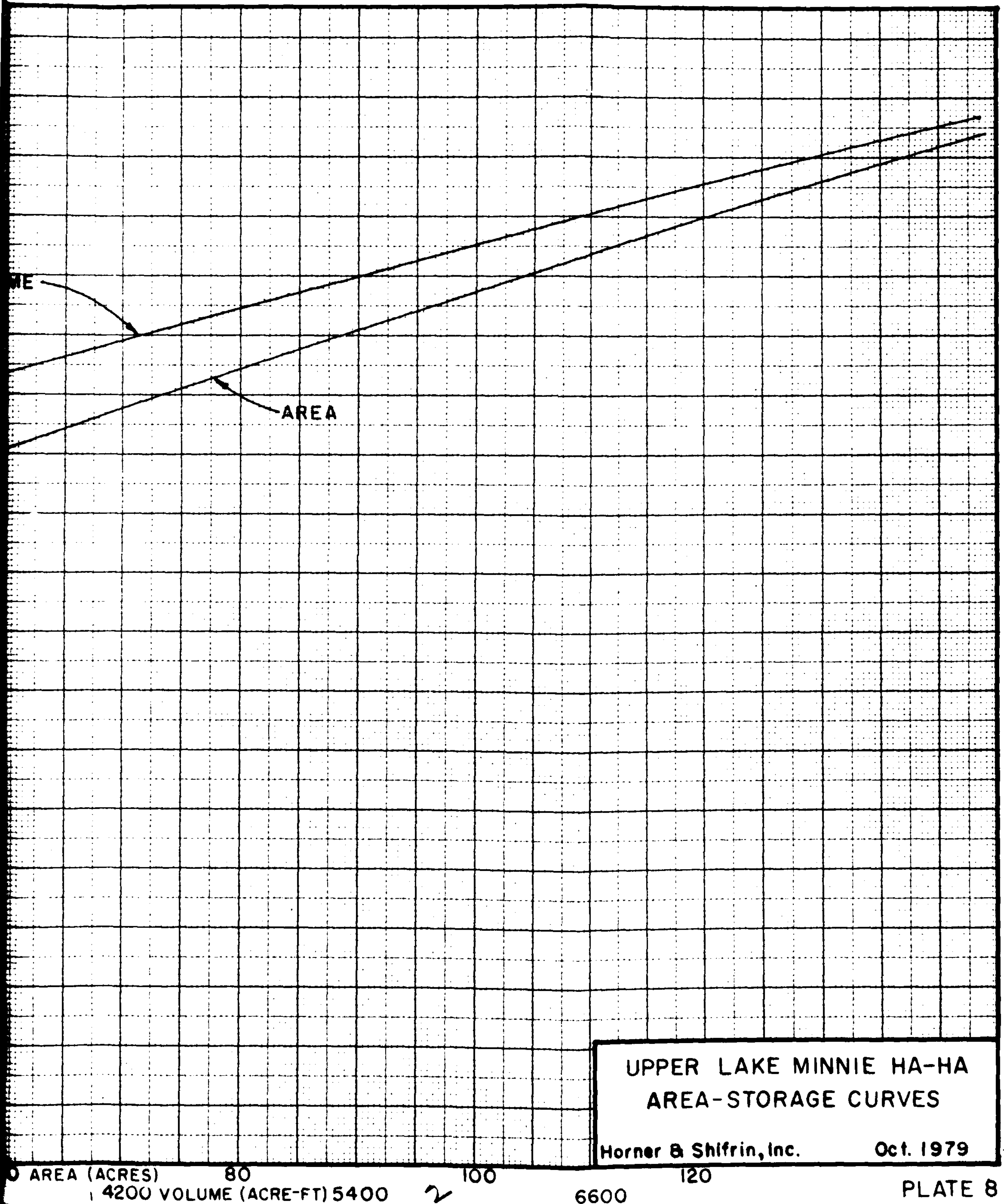
PLATE 7


STORAGE VOLUME
ELEV (M.S.L.)
600
580
560
540
520
500
480
460
440
420
0
20
40
60 AREA (ACRES)
0
600
1800
3000
4200 VOL

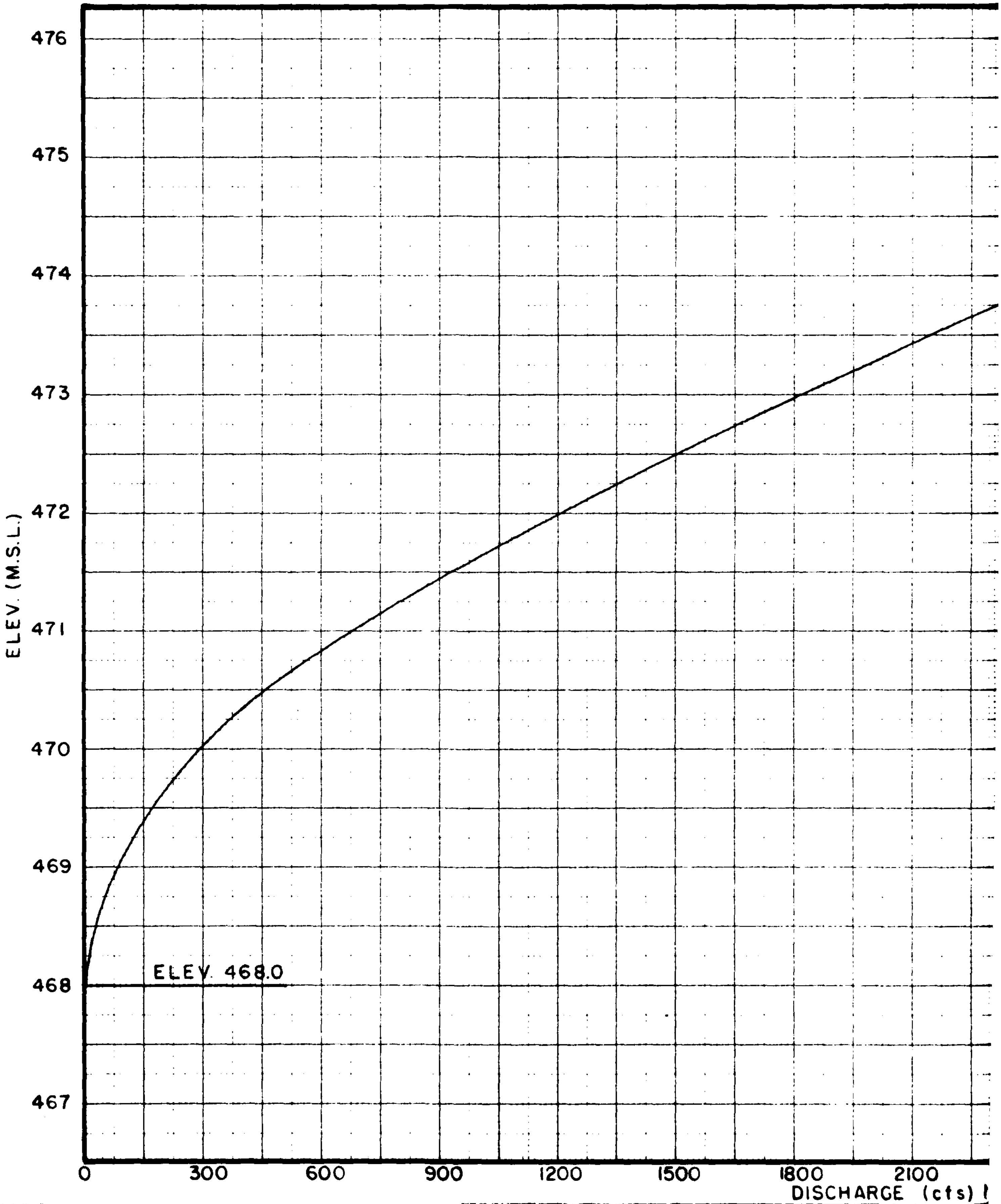


UPPER LAKE MINNIE HA-HA
AREA-STORAGE CURVES

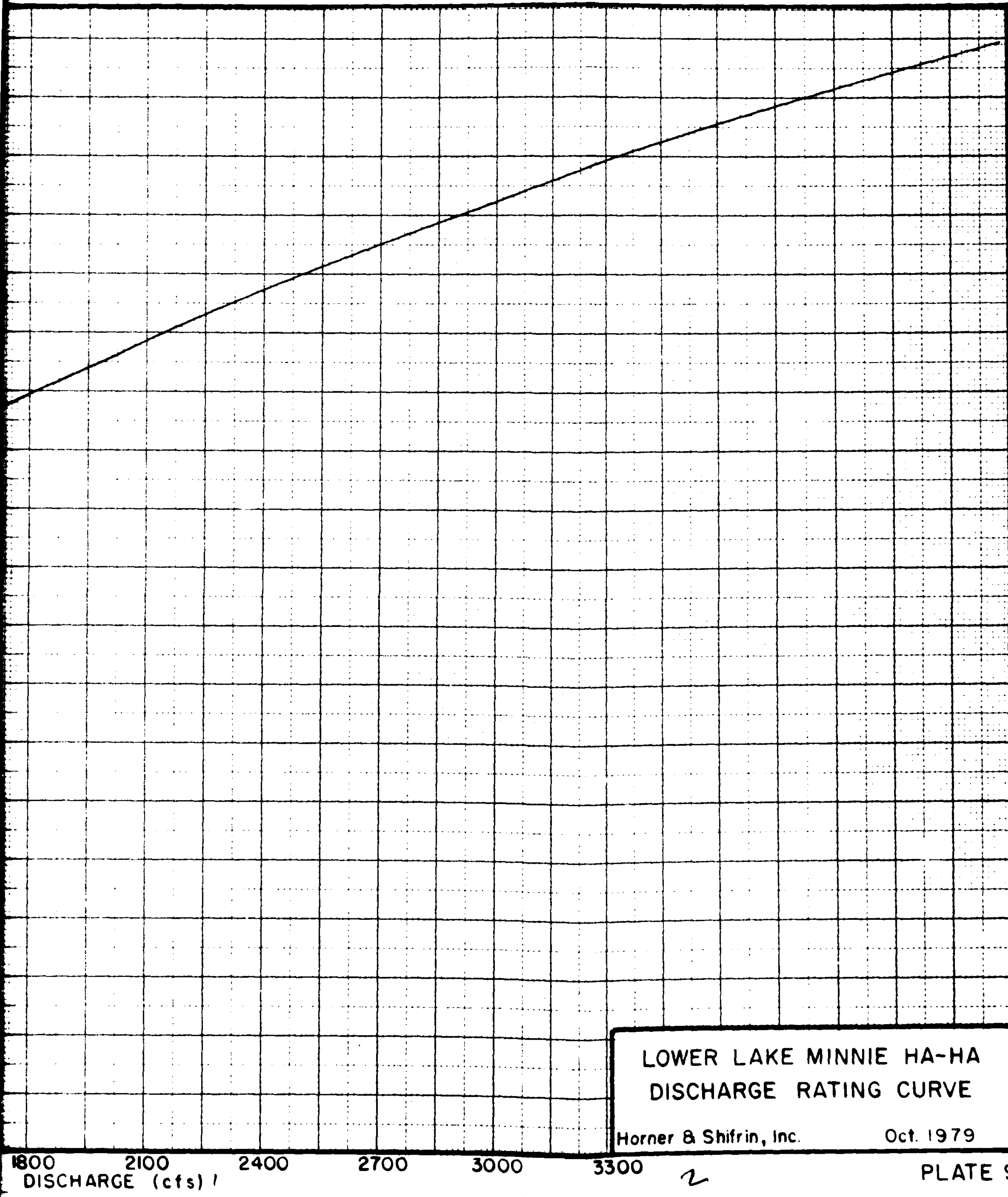
Horner & Shifrin, Inc. Oct. 1979

PLATE 8

2



476
475
474
473
472
471
470
469
468
467
ELEV. (M.S.L.)
ELEV. 468.0
0
300
600
900
1200
1500
1800
2100
DISCHARGE (cfs)

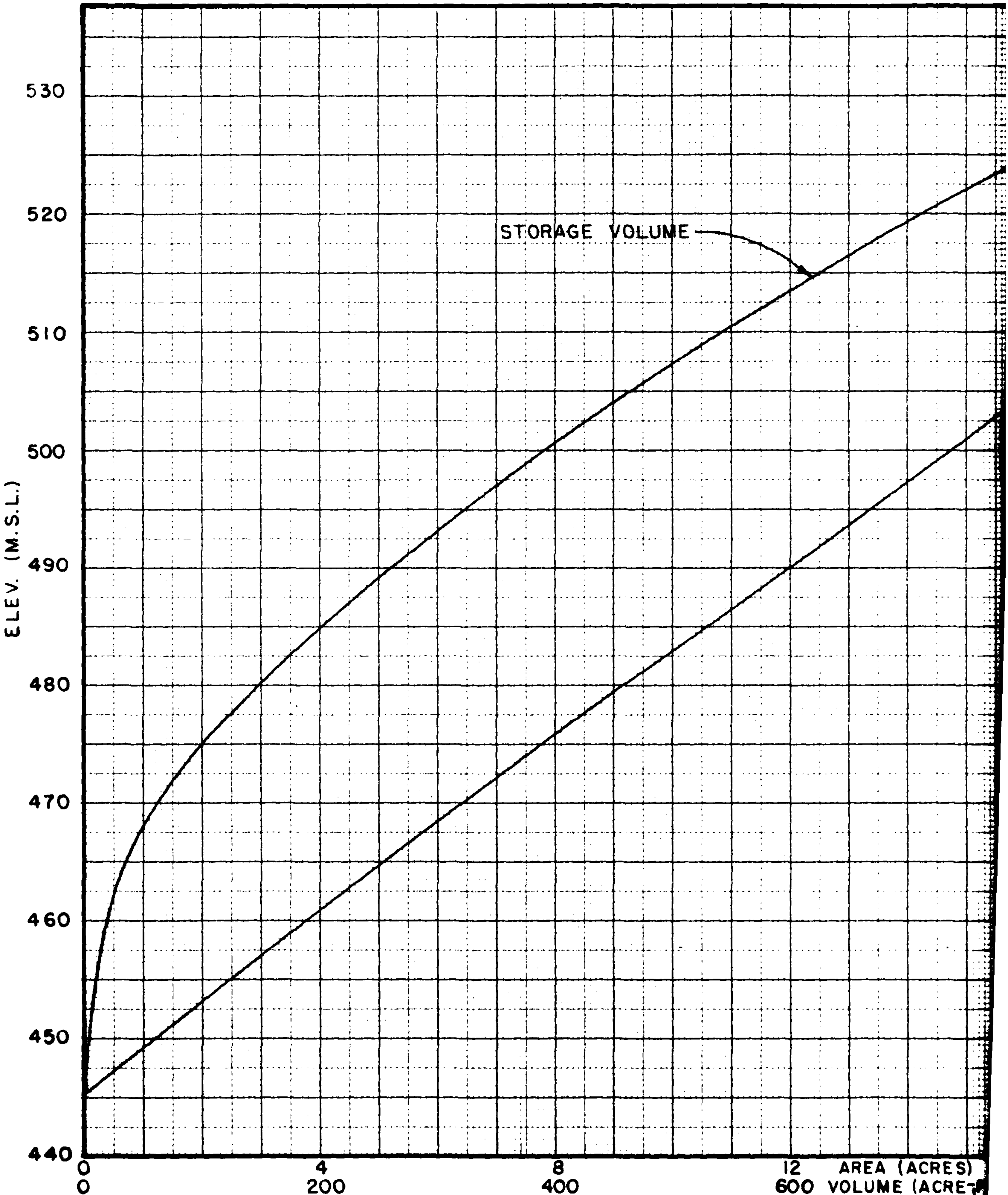


LOWER LAKE MINNIE HA-HA
DISCHARGE RATING CURVE

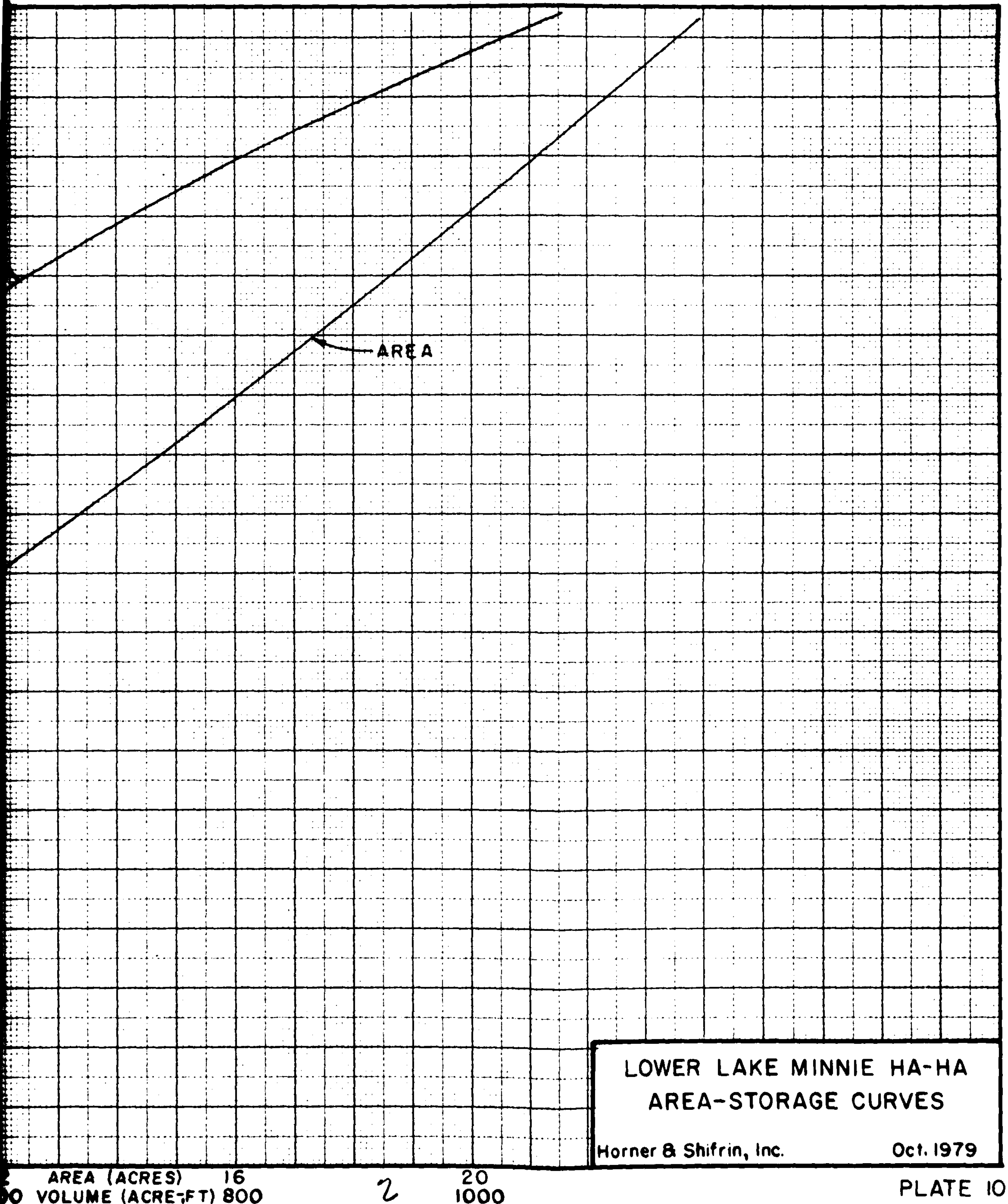
Horner & Shifrin, Inc. Oct. 1979

2

PLATE 9



530
520
510
500
490
480
470
460
450
440
ELEV. (M.S.L.)
STORAGE VOLUME
0
4
8
12
AREA (ACRES)
0
200
400
600
VOLUME (ACRE-



LOWER LAKE MINNIE HA-HA
AREA-STORAGE CURVES

Horner & Shifrin, Inc. Oct. 1979

PLATE 10

2

DON HEIL LAKE SITE, STE. GENEVIEVE COUNTY, MISSOURI

The proposed lake site is in the central part of the E½ sec. 20, T. 36 N., R. 9 E., Ste. Genevieve County, Missouri. A 40 foot high earthen fill dam, located in the NW¼ NE¼ NE¼ SE¼ sec. 20, T. 36 N., R. 9 E., is proposed which would create a lake of about 25 acres. The drainage to lake ratio is approximately 20:1.

Bedrock exposed in the reservoir area is the Roubidoux sandstone and dolomite, and the overlying Jefferson City dolomite. The gravels in the stream are very coarse indicating rapid runoff in the valley. The stream channel is one of scour and fill.

Soil cover along the hillside to the northeast is shallow and contains a heavy concentration of chert especially along the lower part of the hill-slope. The ridge above the southwest abutment is capped by a reddish-brown silty clay.

Reservoir area.-- The bedrock exposed along the bed of the stream and in the lower part of the hillslopes is sandstone with interbedded dolomite layers and chert beds. The sandstone is thin to medium bedded. The quartz grains are fine to medium grained and angular. The dolomites are generally dense and medium bedded. The bedrock is jointed or fractured at nearly every outcrop observed.

Water loss within the reservoir will be through the open joints and along bedding planes in the bedrock. No solution phenomenon in the dolomite beds was noted.

Dam site.-- The southwest abutment will tie into a soil slope of firm silty clay. The northeast abutment is a small bluff of sandstone overlying

a dolomite. Above the bluff the hillslope is covered by heavy concentrated residual cherts intermixed with a thin soil cover.

Borrow material.-- The silty clay capping the elongated ridge above the southeast abutment will be suitable for fill and core material. Approximately 750,000 cubic yards is estimated from a number of shallow auger holes.

Water loss.-- Water loss within the reservoir area will be through the open joints and along bedding planes in the bedrock. No solution phenomenon was noted in the dolomite beds as previously mentioned.

Recommendations:

1. Core trench carried to bedrock along the base and cut into the bluff on the northeast abutment.

2. Tie west abutment into soil slope if the soil is sufficiently thick.

3. Bedrock along the center line of the dam and at the east abutment should be drilled to a depth of 25± feet to determine its tightness. A water circulating rotary rig should be used for the drilling. Pressure testing of these holes is also advisable. If water loss is high during drilling the site should be abandoned.

4. All organic material should be stripped from beneath the fill area. Trees, brush, etc., should be burned outside of the area to be covered by the fill.

5. A clay padding should be placed over the present stream channel beneath the fill area and for a short distance upstream beyond the toe of the dam.

From the reconnaissance survey the water tightness of the bedrock does not appear to be favorable. All indications are that it may be

necessary to grout with cement to insure a minimum water loss. For this reason the drilling of the bedrock along the centerline of the dam and at the east abutment is recommended. At least two holes in the valley bottom and one in the east abutment should be drilled. Unless the soil covering west abutment is extremely shallow it should not be necessary to drill the western edge of the dam site.

If water loss is appreciable and persistent during the drilling operation, the site should be abandoned unless provisions are available for extensive grouting. If all holes are water tight then it may be considered that the site is favorable, but still one where there is opportunity for some water loss. The Roubidoux sandstone formation with its typical, persistent joint development is not generally a water tight rock. Consequently any reservoir development in the Roubidoux should be undertaken with the anticipation of possible failure.

James A. Martin

James H. Williams
August 21, 1962
Missouri Geological Survey

James A. Martin

James A. Martin
August 21, 1962
Missouri Geological Survey

Ste Genevieve
Eng Geol
Reservoir

October 16, 1962

Mr. Don Heil
Ste. Genevieve, Missouri

Dear Mr. Heil:

I visited your lake site October 10th, and consider your upstream relocation will add much to the reliability of the reservoir location. The present site of the dam and lake is in the most suitable area that is available along the stream valley. The bedrock is the lower part of the Jefferson City dolomite, and is generally considered to be about as water tight as any bedrock formation in eastern Missouri. The underlying formation, the Roubidoux sandstone, which is present a short distance downstream, is probably five to eight feet below the stream bed along the centerline of the dam. The chert beds apparent in the stream channel along the centerline are indicative of the nearness of the underlying Roubidoux. Since the Roubidoux which is a possible waterloss hazard is relatively near the surface in this area, I would suggest that you leave as much soil cover as feasible on the floodplain of the valley. Since the floodplain sediments consist of gravelly soil, some water loss may occur if too much of this soil is stripped for fill material. Excavation of borrow material along the planned pool level will aid in reduction of weed and brush growth along the shoreline. Another suggestion that you might consider is that some dams are benched along the waterline and Canary grass or a similar hardy vegetation is sown to reduce wave scour and avoid use of rock riprap. This has been done for some lakes in northeastern Missouri, but I am not aware of any in the Ste. Genevieve county area where it has been tried.

Very truly yours,

James H. Williams
Engineering Geologist

JHW: gmo

cc: Mr. Warren H. Hargus

Chart 2-4

APPENDIX A

INSPECTION PHOTOGRAPHS

UPPER LAKE MINNIE HA-HA DAM

NO. 1: UPSTREAM FACE OF DAM

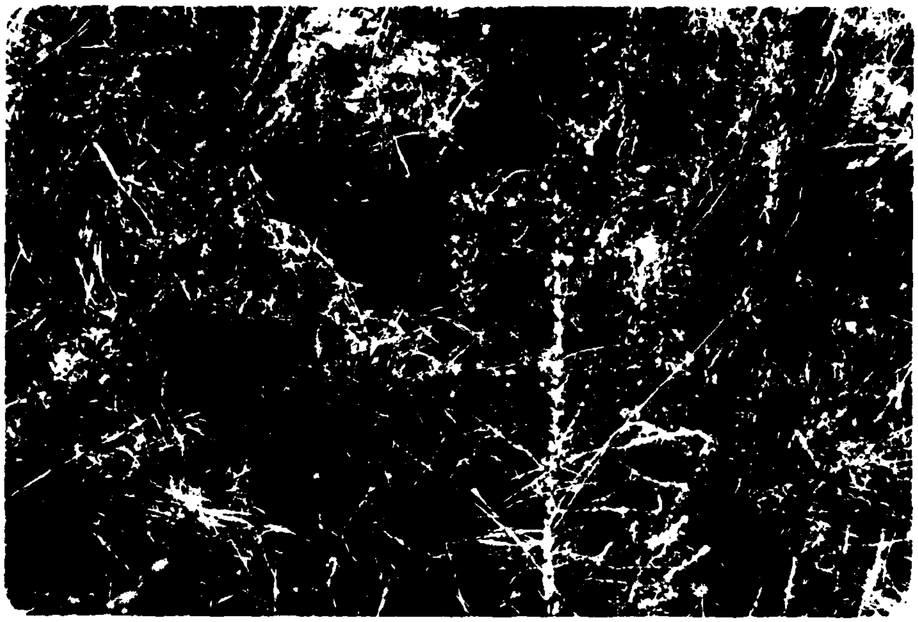
NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: SPILLWAY APPROACH CHANNEL

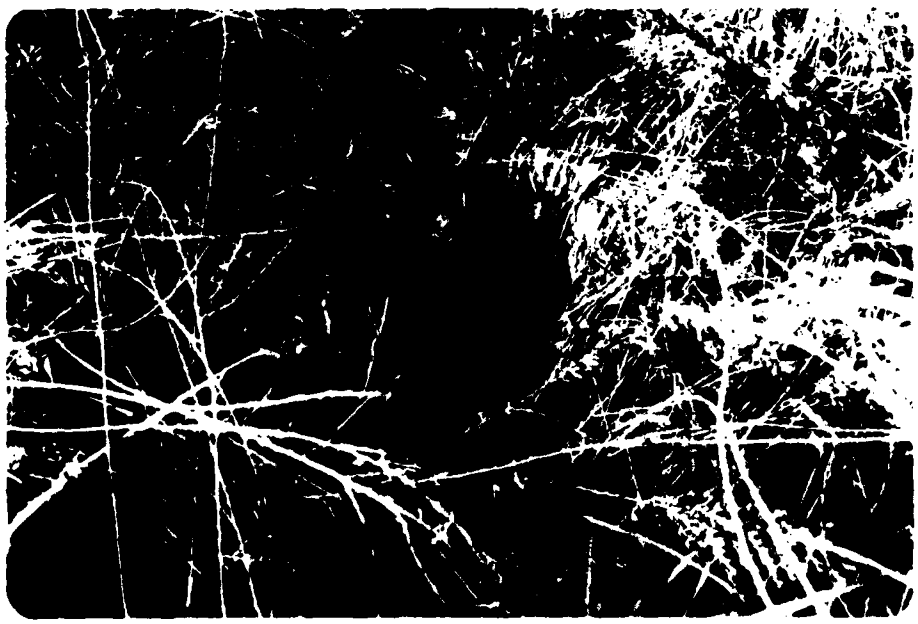
NO. 4: SPILLWAY [illegible]

NO. 5: SPILLWAY OUTLET CHANNEL (LOOKING DOWNSTREAM)

NO. 6: LOWER END OF SPILLWAY OUTLET CHANNEL



NO. 7: SEEPAGE NEAR RIGHT ABUTMENT



NO. 8: ANIMAL BURROW IN DOWNSTREAM FACE OF DAM

LOWER LAKE MINNIE HA-HA DAM

NO. 9: UPSTREAM FACE OF DAM

NO. 10: DOWNSTREAM FACE OF DAM

NO. 11: SPILLWAY APPROACH AND CREST

NO. 12: SPILLWAY OUTLET CHANNEL

LOWER LAKE MINNIE HA-HA DAM

NO: 13: VALVE ON LAKE DRAWDOWN PIPE

NO. 14: STANDING WATER BELOW DAM

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. The probable maximum precipitation (200 sq. mile, 24-hour value equals 26.5 inches) was obtained from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers.

b. Drainage areas:

(1) Upper Lake Dam = 0.40 square miles = 256 acres

(2) Lower Lake Dam = 0.04 square miles = 26 acres (incremental)

c. SCS parameters:

(1) Upper Lake Dam.

Lag time = 0.086 hours

Soil type CN = 84 (Soil type B, AMC III)

= 68 (Soil type B, AMC II)

(2) Lower Lake Dam.

Lag time = 0.039 hours

Soil type CN = 84 (Soil type B, AMC III)

= 68 (Soil type B, AMC II)

Lag Time = 0.60 Tc (SCS Method)

Time of Concentration (Tc) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$

Where Tc = Travel time of water from hydraulically most distant point to point of interest, hours.

L = Length of longest watercourse, miles.

H = Elevation difference, feet.

2. The spillways consist of broad-crested, trapezoidal sections for which conventional weir formulas do not apply. Spillway release rates for these sections were determined as follows:

a. Spillway crest section properties (area, "a" and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth (Qc) was computed as:
$Qc = \left(\frac{a^3 g}{t}\right)^{0.5}$ for the various depth, "d". Corresponding velocities (Vc) and velocity heads (Hvc) were determined using conventional formulas.

c. Static lake levels corresponding to the various flows passing over the spillway were computed as critical depths plus critical velocity heads (dc + Hvc) and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

3. The profile of each dam crest proper is irregular and flow over the dam crest cannot be determined by conventional weir formulas. Crest length and elevation data for the dam crests proper were entered into the HEC-1 Program on the $L and the $V cards. The program computes internally the flow over the dam crest and adds this flow to the flow over the spillway as entered on the Y4 and Y5 cards.

UPPER LAKE MINNIE HA-HA DAM

```
A1        ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2        HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF MINNI-HA-HA LAKE DAM
A3        RATIOS OF PMF ROUTED THROUGH RESERVOIR
B      288       0       5                                               0
B1       5
J        1       6       1
J1     .16     .17     .18     .19     .50     1.0
K        0  INFLOW                                       1
K1        INFLOW HYDROGRAPH
M        1       2    0.40                     1.0                       1
P        0    26.0     102     120     130
T                                                       -1     -84
W2               0.096
X     -1.0    -.10     2.0
K        1     DAM                                       1
K1        RESERVOIR ROUTING BY MODIFIED PULS
Y                                1       1
Y1       1                                           392.5      -1
Y4   494.0   494.6   495.3   496.1   496.8   498.2   499.6   500.9
Y5       0    19.9   103.4   231.4   392.8   807.1  1324.6  1963.5
$A       0    18.4    26.6    45.0    75.3   102.8   137.7
$E     430     494     500     520     540     560     580
$S     494
$D   496.4
$L      60     117     171     314     375     417     519     574     592     593
$V   496.5   496.5   496.7   496.8   496.9   497.0   497.5   498.0   499.0   599.0
K       99
```

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	493.99	494.00	496.40
STORAGE	392.	393.	440.
OUTFLOW	0.	0.	301.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.16	496.26	0.00	437.	268.	0.00	16.00	0.00
.17	496.36	0.00	440.	291.	0.00	15.92	0.00
.18	496.46	.06	442.	314.	.42	15.92	0.00
.19	496.55	.15	444.	339.	.67	15.92	0.00
.50	497.80	1.40	472.	2301.	4.67	15.75	0.00
1.00	498.61	2.21	491.	5000.	7.00	15.67	0.00

```
A1      ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2      HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF MINNI-HA-HA LAKE DAM
A3      RATIOS OF PMF ROUTED THROUGH RESERVOIR
B      288       0       5                                               0
B1       5
J        1       6       1
J1     .30     .31     .32     .33     .50     1.0
K        0  INFLOW                                       1
K1      INFLOW HYDROGRAPH
M        1       2    0.40                     1.0                       1
P        0    26.0     102     120     130
T                                                       -1     -84
W2           0.086
X     -1.0    -.10     2.0
K        1     DAM                                       1
K1      RESERVOIR ROUTING BY MODIFIED PULS
Y                                1       1
Y1       1                                           392.5      -1
Y4   494.0   494.6   495.3   496.1   496.8   498.2   499.6   500.9
Y5       0    19.9   103.4   231.4   392.8   807.1  1324.6  1963.5
$A       0    18.4    26.6    45.0    75.3   102.6   137.7
$E     430     494     500     520     540     560     580
$$     494
$D   495.4
$L      50     117     171     314     375     419     519     574     592     593
$V   496.5   496.6   496.7   496.8   496.9   497.0   497.5   498.0   499.0   599.0
K         INFLOW2
K1        INFLOW HYDROGRAPH TO LOWER LAKE
M        1       2    0.34                     1.0                       1
P        0    26.0     102     120     130
T                                                       -1     -84             .25
W2           0.039
X     -1.0    -.10     2.0
K        2    COMB
K1      COMBINED   INFLOW
K        1    DAM2
K1      RESERVOIR ROUTING BY MODIFIED PULS
Y                                1       1
Y1       1                                              53      -1
Y4   468.0   468.6   469.3   470.2   470.7   471.4   472.1   474.5   474.9   476.1
Y4   477.4
Y5       0      30     157     346     594     900    1245    2145    3239    4435
Y5    5875
$A       0     6.4     9.2    14.7    19.9    24.8
$E   443.2   468.0     480     500     520     540
$$   468.0
$D   471.5
$L       6      22      31      54      74     186     282     288     289     292
$V   471.6   471.7   471.8   471.9   472.0   472.5   473.0   473.5   474.0   476.0
K       99
```

COMBINED UPPER & LOWER LAKES

UPPER LAKE MINNIE HA-HA DAM

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	493.99	494.00	496.40
STORAGE	392.	393.	440.
OUTFLOW	0.	0.	301.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.30	497.23	.83	459.	1020.	2.00	15.75	0.00
.31	497.27	.87	460.	1101.	2.17	15.75	0.00
.32	497.32	.92	461.	1180.	2.25	15.75	0.00
.33	497.35	.95	462.	1256.	2.33	15.75	0.00
.50	497.80	1.40	472.	2301.	4.67	15.75	0.00
1.00	498.61	2.21	491.	5000.	7.00	15.67	0.00

LOWER LAKE MINNIE HA-HA DAM

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	468.01	468.00	471.50
STORAGE	53.	53.	77.
OUTFLOW	1.	0.	949.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.30	471.35	0.00	76.	877.	0.00	15.92	0.00
.31	471.48	0.00	76.	940.	0.00	15.92	0.00
.32	471.60	.10	77.	1000.	.17	15.92	0.00
.33	471.72	.22	78.	1061.	.25	15.92	0.00
.50	473.04	1.54	88.	2198.	.67	15.83	0.00
1.00	474.57	3.07	100.	5375.	3.08	15.75	0.00

```
A1       ANALYSIS OF DAM OVERTOPPING USING 100YR FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF MINNI-HA-HA LAKE DAM
A3       100YR FLOOD ROUTED THROUGH RESERVOIR
B      288       0       5                                       0
B1       5
J        1       1       1
J1     1.0     .10     .15     .20     .25     .30    0.40     .50    1.00
K        0  INFLOW                                       1
K1       INFLOW HYDROGRAPH
M        0       2    0.40                     1.0                       1
O      288
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
O1    .013    .013    .013    .013    .024    .024    .024    .024    .024    .024
O1    .024    .024    .024    .024    .024    .024    .024    .024    .024    .024
O1    .024    .024    .031    .031    .031    .031    .031    .031    .049    .049
O1    .049    .049    .049    .049    .139    .138    .139    .262    .262    .544
O1    .813    .378    .262    .139    .139    .138    .049    .049    .049    .049
O1    .049    .049    .031    .031    .031    .031    .031    .031    .024    .024
O1    .024    .024    .024    .024    .024    .024    .024    .024    .024    .024
O1    .024    .024    .024    .024    .024    .024    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007
T                                                       -1     -68
W2            0.086
X     -1.0    -.10     2.0
K        1     DAM                                       1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                                        1       1
Y1       1                                           392.5      -1
Y4   494.0   494.6   495.3   496.1   496.8   498.2   499.6   500.9
Y5       0    19.9   103.4   221.4   392.8   807.1  1324.6  1963.5
$A       0    18.4    26.6    45.0    75.3   102.8   137.7
$E     430     484     500     520     540     560     580
$$     494
$D   496.4
$L      60     117     171     314     375     419     519     574     592     593
$V   496.5   496.6   496.7   496.8   496.9   497.0   497.5   498.0   499.0   599.0
```

```
K        INFLOW2
K1       INFLOW HYDROGRAPH TO LOWER LAKE
M       0       2     0.04                        1.0                          1
C     288
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .013    .013    .013    .013    .013    .013    .013    .013
C1   .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
C1   .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
C1   .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
C1   .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
C1   .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
C1   .013    .013    .013    .013    .013    .013    .013    .013    .013    .013
C1   .013    .013    .013    .013    .024    .024    .024    .024    .024    .024
C1   .024    .024    .024    .024    .024    .024    .024    .024    .024    .024
C1   .024    .024    .031    .031    .031    .031    .031    .031    .049    .049
C1   .049    .049    .049    .049    .138    .138    .139    .262    .262    .544
C1   .613    .378    .262    .139    .138    .138    .049    .049    .049    .049
C1   .049    .049    .031    .031    .031    .031    .031    .031    .024    .024
C1   .024    .024    .024    .024    .024    .024    .024    .024    .024    .024
C1   .024    .024    .024    .024    .024    .024    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
C1   .007    .007    .007    .007    .007    .007    .007    .007
T                                                       -1     -68              .25
W2          0.039
X    -1.0    -.10     2.0
K       2    COMB
K1      COMBINED  INFLOW
K       1    DAM2
K1      RESERVOIR ROUTING BY MODIFIED PULS
Y                                1       1
Y1      1                                                53      -1
Y4  468.0   468.5   469.3   470.2   470.7   471.4   472.1   474.5   474.9   476.1
Y4  477.4
Y5      0      30     157     346     504     900    1245    2145    3239    4435
Y5   5875
$A      0     6.4     9.2    14.7    19.9    24.8
$E  443.2   468.0     480     500     520     540
$$  468.0
$D  471.5
$L      6      22      31      54      74     186     282     288     289     292
$V  471.6   471.7   471.8   471.9   472.0   472.5   473.0   473.5   474.0   476.0
K      99
```

100-YEAR FLOOD

LOWER LAKE MINNIE HA-HA DAM

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	468.01	468.00	471.50
STORAGE	53.	53.	77.
OUTFLOW	1.	0.	949.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	469.56	0.00	63.	211.	0.00	16.08	0.00

UPPER LAKE MINNIE HA-HA DAM

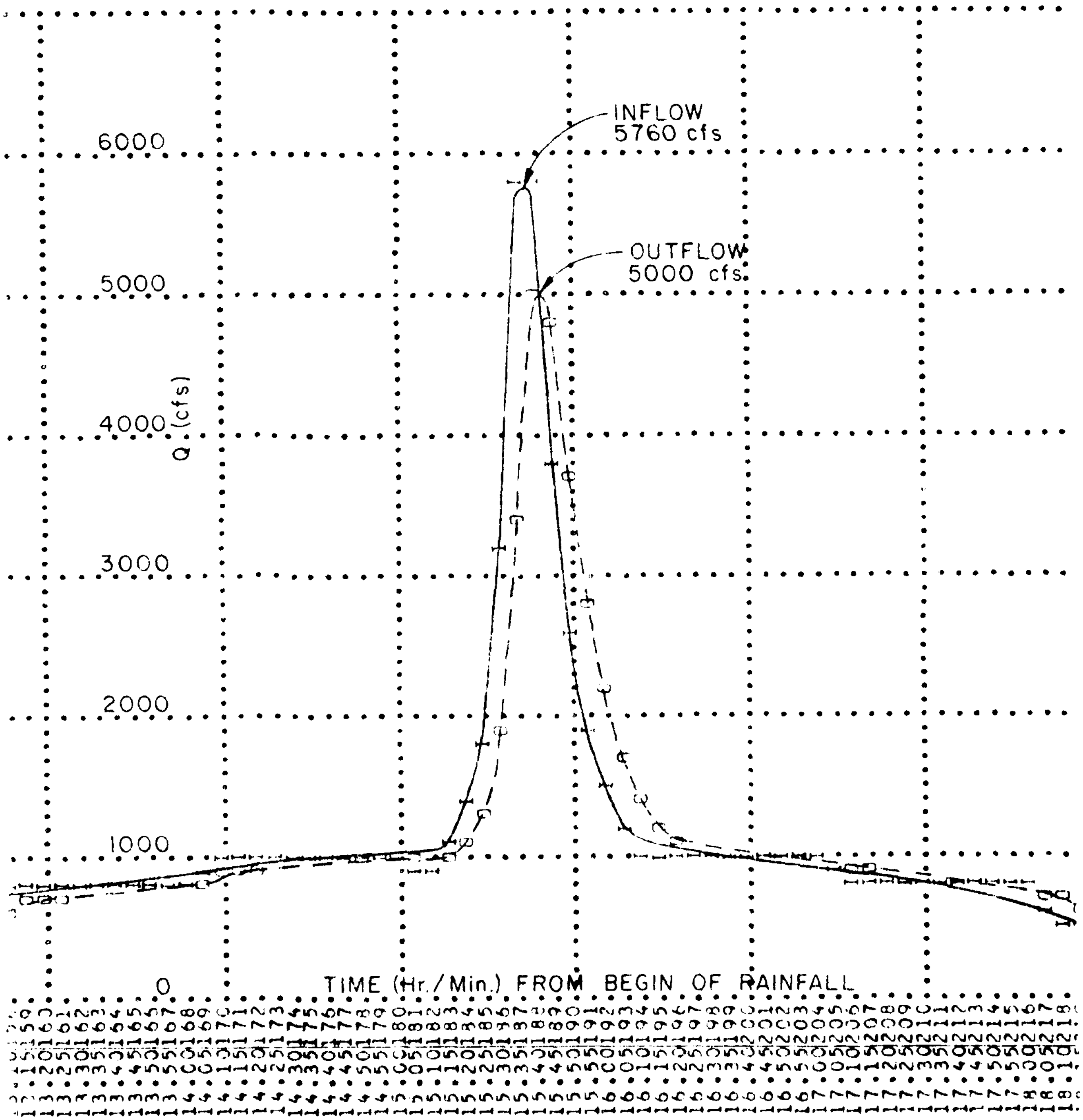
SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	493.99	494.00	496.40
STORAGE	392.	393.	440.
OUTFLOW	0.	0.	301.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	496.05	0.00	433.	223.	0.00	15.58	0.00

UPPER LAKE MINNIE HA-HA
PMF INFLOW & OUTFLOW
HYDROGRAPHS

Horner & Shifrin, Inc. Oct. 1979



LOWER LAKE MINNIE HA-HA
PMF INFLOW & OUTFLOW
HYDROGRAPHS

Horner & Shifrin, Inc. Oct. 1979